

## SECTION 6

### WASTEWATER TREATMENT TECHNOLOGIES

This section describes the technologies available for the treatment of wastewater generated by the 84 commercial facilities within the Industrial Waste Combustor (IWC) Industry. This section also presents an evaluation of performance data on treatment systems collected by EPA during field sampling programs and the rationale used in the development of the proposed regulatory options. Specifically, Section 6.1 describes the technologies used by commercial IWC facilities to treat air pollution control, flue gas quench, and ash/slag quench wastewaters, which are the only types of wastewater proposed for regulation. Section 6.2 describes technologies used by commercial IWC facilities for the treatment of wastewater generated as a result of IWC operations (e.g. container wash water and truck wash water) for which EPA is not proposing regulations. Section 6.3 lists technologies used by commercial IWC facilities for the treatment of wastewater generated as a result of other operations on-site (e.g. landfill leachate and sanitary water). Section 6.4 presents the EPA performance data on selected treatment technologies, as well as, the rationale used in selecting the treatment technologies for the regulatory options.

Of the 84 commercial IWC facilities, 39 facilities generate no wastewater. A breakdown of the types of wastewaters collected at the remaining 45 commercial IWC facilities which generate wastewater is as follows:

<u>Type of wastewater collected</u>	<u>Number of commercial IWC facilities</u>
IWC wastewaters only (air pollution control, ash/slag quench, flue gas quench)	8
wastewaters generated from IWC operations only (container, area, and truck wash waters)	7
other on-site wastewaters only (sanitary wastewater, leachates)	9
IWC wastewaters and wastewaters generated from IWC operations	15
IWC wastewaters, wastewaters generated from IWC operations, and other on-site wastewaters	3
wastewaters generated from IWC operations and other on-site wastewaters	3

As demonstrated above, only 26 of the 84 commercial IWC facilities generate IWC wastewaters and therefore, were considered to be within the scope of this proposed regulation.

## **6.1            *AVAILABLE BAT AND PSES TECHNOLOGIES***

Commercial IWC facilities use either physical/chemical treatment technology to treat IWC wastewaters or treatment and disposal methods that result in no discharge of IWC wastewaters.

Through its CWA Section 308 Questionnaire, EPA obtained information on nine different wastewater treatment technologies currently in use by the 26 commercial IWC facilities for the treatment of air pollution control, flue gas quench, and ash/slag quench wastewater. In addition, EPA collected other detailed information on available technologies from engineering plant visits to a number of IWC facilities. The data presented in Section 6.4 are based on these data collection activities.

### **6.1.1            *Physical/Chemical Treatment***

#### **6.1.1.1            *Equalization***

Wastewater generation rates at incinerators are sometimes variable due to variations in burn rates and system down times. To allow for the equalization of pollutant loadings and flow rates, IWC wastewaters may be collected in tanks or lined ponds prior to treatment. These are designed with sufficient capacity to hold the peak flows and thus dampen the variation in hydraulic and pollutant loads. Minimization of this variability increases the performance and reliability of down stream treatment systems, and can reduce the size of subsequent treatment by reducing the maximum flow rates and concentrations of pollutants that they will experience. Equalization also lowers the operating costs of associated treatment units by reducing instantaneous treatment capacity demand and by optimizing the amount of treatment chemicals required for a less erratic set of treatment variables. The EPA's Section 308 Questionnaire database identifies 12 facilities that use equalization technology as part of their treatment of IWC wastewaters.

Equalization systems consist of steel or fiberglass holding tanks or lined ponds that provide sufficient capacity to contain peak flow conditions and wastewater volumes of high pollutant loadings. Detention times can vary from a few hours to several days, with one day being a typical value. Some equalization systems contain mechanical mixing systems that enhance the equalization process.

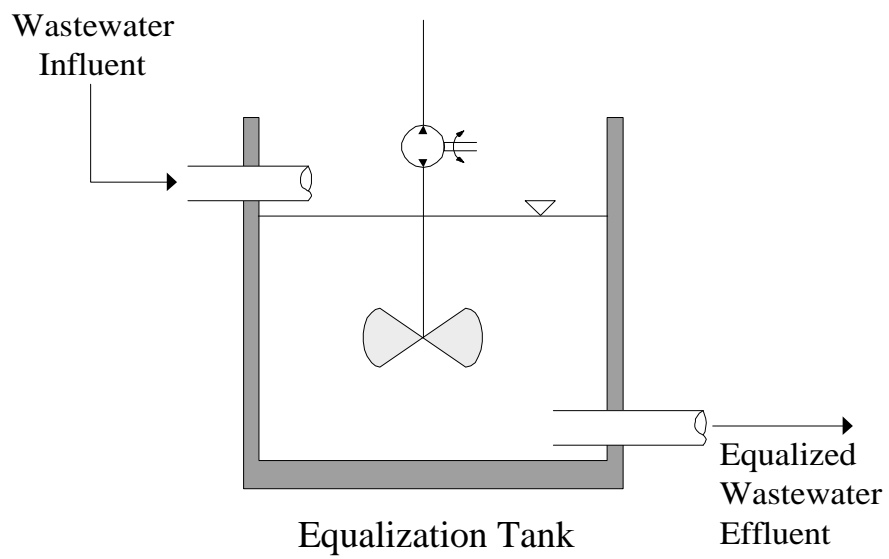
A breakdown of equalization systems used is as follows:

<u>Equalization Type</u>	<u>Number of Units</u>
Unstirred	8
Mechanically stirred	4

A typical equalization system is shown in Figure 6-1.

#### **6.1.1.2 Neutralization or pH Control**

In the treatment of IWC wastewaters, neutralization or pH control systems are used in conjunction with certain chemical treatment processes, such as chemical precipitation, to adjust the pH of the wastewater to optimize process control. Acids, such as sulfuric acid or hydrochloric acid, are added to reduce pH, whereas, alkalis, such as sodium hydroxides, are added to raise pH values. Neutralization may be performed in a holding tank, rapid mix tank, or an equalization tank. Neutralization systems are widely used at IWC facilities for pH control in chemical precipitation systems. Chemicals, such as sodium hydroxide or lime, are frequently used in order to raise the pH of the wastewater to a range somewhere between 9 to 12 in order to optimize precipitation of metal compounds. Acids, such as hydrochloric acid, is also used in conjunction with ferric chloride for chemical precipitation. Neutralization systems at the end of a treatment system are typically designed to control the pH of the discharge to between 6 and 9. There are 16 neutralization systems in place among the commercial IWC facilities that use various caustic and/or alkalis to treat IWC wastewaters. A breakdown of these neutralization systems is as follows:



**Figure 6-1. Equalization**

<u>Type of Neutralization</u>	<u>Number of Units</u>
Caustic	5
Lime	1
Acid	3
Multiple chemicals	6
Other	1

Figure 6-2 presents a flow diagram for a typical neutralization system.

### **6.1.1.3 Flocculation**

Flocculation is a treatment technology used to enhance sedimentation or filtration treatment. Flocculation precedes these processes and consists usually of a rapid mix tank, or in-line mixer and a flocculation tank. The waste stream is initially mixed while a flocculation chemical is added. Flocculants adhere readily to suspended solids and each other to facilitate gravity sedimentation or filtration. Coagulants can be added to reduce the electrostatic surface charges and enhance the formation of complex hydrous oxides. Coagulation allows for the formation of larger, heavier particles, or flocculants (which are usually formed in a flocculation chamber), that can settle faster. There are three different types of flocculants commonly used; inorganic electrolytes, natural organic polymers, and synthetic polyelectrolytes. The selection of the specific treatment chemical is highly dependent upon the characteristics and chemical properties of the contaminants. A rapid mix tank is usually designed for a detention time ranging from 15 seconds to several minutes. After mixing, the coagulated wastewater flows to a flocculation basin where slow mixing of the waste occurs. The slow mixing allows for the particles to agglomerate into heavier, more settleable solids. Mixing is provided either by mechanical paddle mixers or by diffused air. Flocculation basins are typically designed for a detention time of 15 to 60 minutes. There are seven flocculation systems used among the commercial IWC facilities used to treat IWC wastewaters.

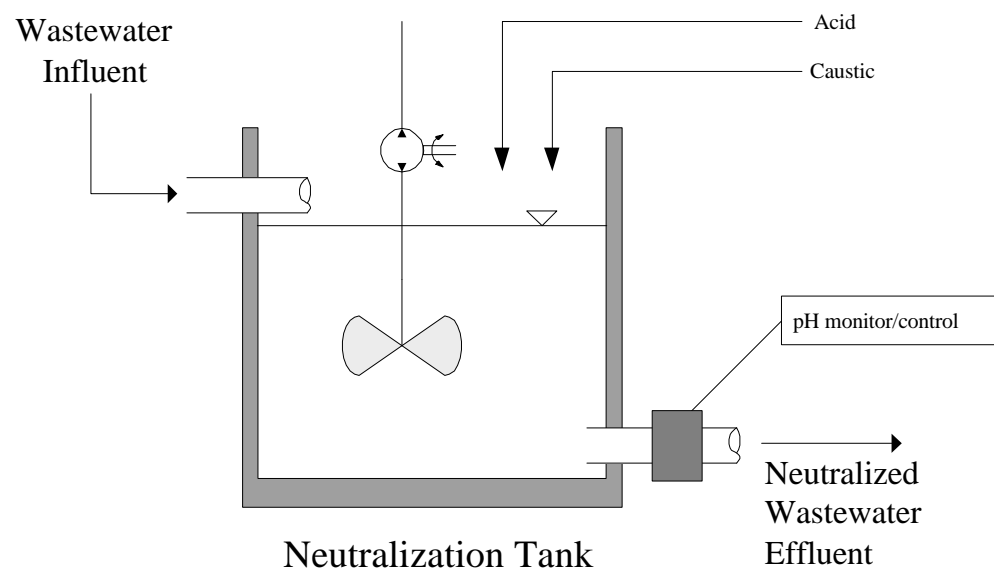


Figure 6-2 Neutralization

#### 6.1.1.4 Gravity-Assisted Separation

Gravity-assisted separation is a simple, economical, and widely used method for the treatment of IWC wastewaters. There are 14 such systems in place at the commercial IWC facilities. Clarification systems remove suspended matter by allowing the wastewater to become quiescent. As a result, suspended matter, which is heavier than water, settles to the bottom, forming a sludge which can be removed. This process may take place in specially designed tanks, or in earthen ponds and basins. Sedimentation units at IWC facilities are typically used as either primary treatment options to remove suspended solids or following a chemical precipitation process.

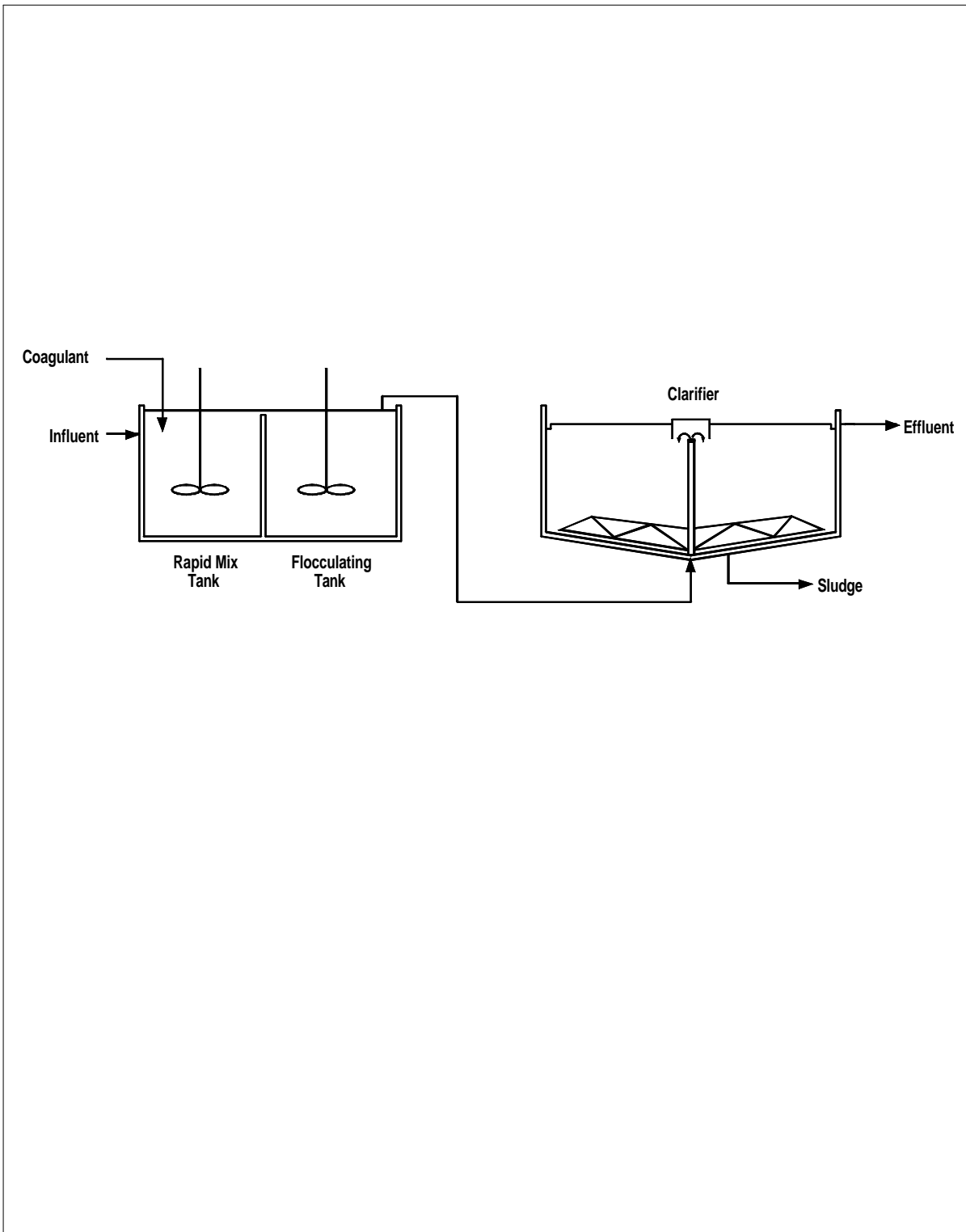
Clarifiers may be rectangular, square, or circular in shape. In rectangular tanks, wastewater flows from one end of the tank to the other with settled sludge collected into a hopper located at one end of the tank. In circular tanks, flow enters from the center and flows towards the outside edge with sludge collected in a center hopper. Treated wastewater exits the clarifier by flowing over a weir located at the top of the clarifier. Sludge which accumulates in the bottom of the clarifiers is periodically removed and is typically stabilized and/or dewatered prior to disposal.

Flocculation systems are commonly used in conjunction with gravity assisted clarification systems in order to improve their solids removal efficiency. Some clarifiers are designed with a center well to introduce flocculants and allow for coagulation in order to improve removal efficiencies. A schematic of a typical clarification system using coagulation and flocculation is shown in Figure 6-3. The main design parameters used in designing a clarifier are the overflow rate, detention time and the side water depth. The overflow rate is the measure of the flow as a function of the surface area of the clarifier. Typical design parameters used for both primary and secondary clarifiers are presented below:

<u>Design Parameter</u>	<u>Primary</u>	<u>Secondary</u>
Overflow rate, gpd/sq ft	600-1,000	500-700
Detention time, min	90-150	90-150
Minimum Side water depth, ft	8	10

Source: ASCE/WEF, *Design of Municipal Wastewater Treatment Plants*, 1991.

There are three facilities that use corrugated plate interceptor technology. These systems include a series of small (approximately 2 inch square) inclined tubes in the clarification settling zone. The suspended matter must only travel a short distance, when settling or floating, before they reach



**Figure 6-3: Clarification System Incorporating Coagulation and Flocculation**



a surface of the tube. At the tubes' surface, the suspended matter further coagulate. Because of the enhanced removal mechanism, corrugated plate interceptor units can have much smaller settling chambers than standard clarifiers.

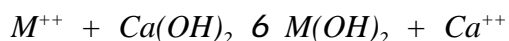
#### **6.1.1.5 Chemical Precipitation**

Chemical precipitation is used for the removal of metal compounds from wastewater. In the chemical precipitation process, soluble metallic ions and certain anions, which are found in IWC wastewaters, are converted to insoluble forms, which precipitate from the solution. Most metals are relatively insoluble as hydroxides, sulfides, or carbonates. Coagulation processes are used in conjunction with precipitation in order to facilitate removal by agglomeration of suspended and colloidal materials. The precipitated metals are subsequently removed from the wastewater stream by liquid filtration or clarification (or some other form of gravity assisted sedimentation). Other treatment processes such as equalization, chemical oxidation or reduction (e.g., hexavalent chromium reduction), precede the chemical precipitation process. The performance of the chemical precipitation process is affected by chemical interactions, temperature, pH, solubility of waste contaminants, and mixing effects. There are a total of nine chemical precipitation systems in use by the commercial IWC facilities to treat IWC wastewater.

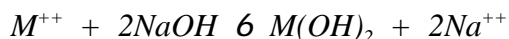
Common precipitation chemicals used in the IWC industry include lime, sodium hydroxide, soda ash, sodium sulfide, and alum. Other chemicals used in the precipitation process for pH adjustment and/or coagulation include sulfuric and phosphoric acid, ferric chloride, and polyelectrolytes. Many facilities use, or have the means to use, a combination of these chemicals. Precipitation using sodium hydroxide or lime is the conventional method of removing metals from wastewater. However, sulfide precipitation is also frequently used instead of hydroxide precipitation in order to remove certain metal ions. Hydroxide precipitation is effective in removing such metals as antimony, arsenic, chromium, copper, lead, mercury, nickel, and zinc. Sulfide precipitation is more appropriate for removing mercury, lead, and silver. Carbonate precipitation, while not frequently used in the Incinerator industry, is another method of chemical precipitation and is used primarily to remove antimony and lead. Alum, another precipitant/coagulant agent infrequently used, forms aluminum hydroxides in wastewaters containing calcium or magnesium bicarbonate alkalinity.

Aluminum hydroxide is an insoluble gelatinous floc which settles slowly and entraps suspended materials. For metals such as arsenic and cadmium, coprecipitation with iron or aluminum is an effective treatment process.

Hydroxide precipitation using lime or sodium hydroxide is the most commonly used means of chemical precipitation in the Incinerator industry, and of these, lime is used more often than sodium hydroxide. The chief advantage of lime over caustic is its lower cost. However, lime is more difficult to handle and feed, as it must be slaked, slurried, and mixed, and can plug the feed system lines. Lime precipitation also produces a larger volume of sludge. The reaction mechanism for precipitation of a divalent metal using lime is shown below:



The reaction mechanism for precipitation of a divalent metal using sodium hydroxide is as follows:



In addition to the type of treatment chemical chosen, another important design factor in the chemical precipitation operation is pH. Metal hydroxides are amphoteric, meaning that they can react chemically as acids or bases. As such, their solubilities increase toward both lower and higher pH levels. Therefore, there is an optimum pH for precipitation for each metal, which corresponds to its point of minimum solubility. Another key consideration in a chemical precipitation application is the detention time in the sedimentation phase of the process, which is specific to the wastewater being treated and the desired effluent quality.

The first step of a chemical precipitation process is pH adjustment and the addition of coagulants. This process usually takes place in separate mixing and flocculation tanks. After mixing the wastewater with treatment chemicals, the resultant mixture is allowed to agglomerate in the flocculation tank which is slowly mixed by either mechanical means, such as mixers, or recirculation pumping. The wastewater then undergoes a separation/dewatering process such as clarification or

filtration, where the precipitated metals are removed from solution. In a clarification system, a flocculent, such as a polymer, is sometimes added to aid in the settling process. The resulting sludge from the clarifier or filter must be further treated, disposed, or recycled. A typical chemical precipitation system is shown in Figure 6-4.

#### **6.1.1.6 Stripping**

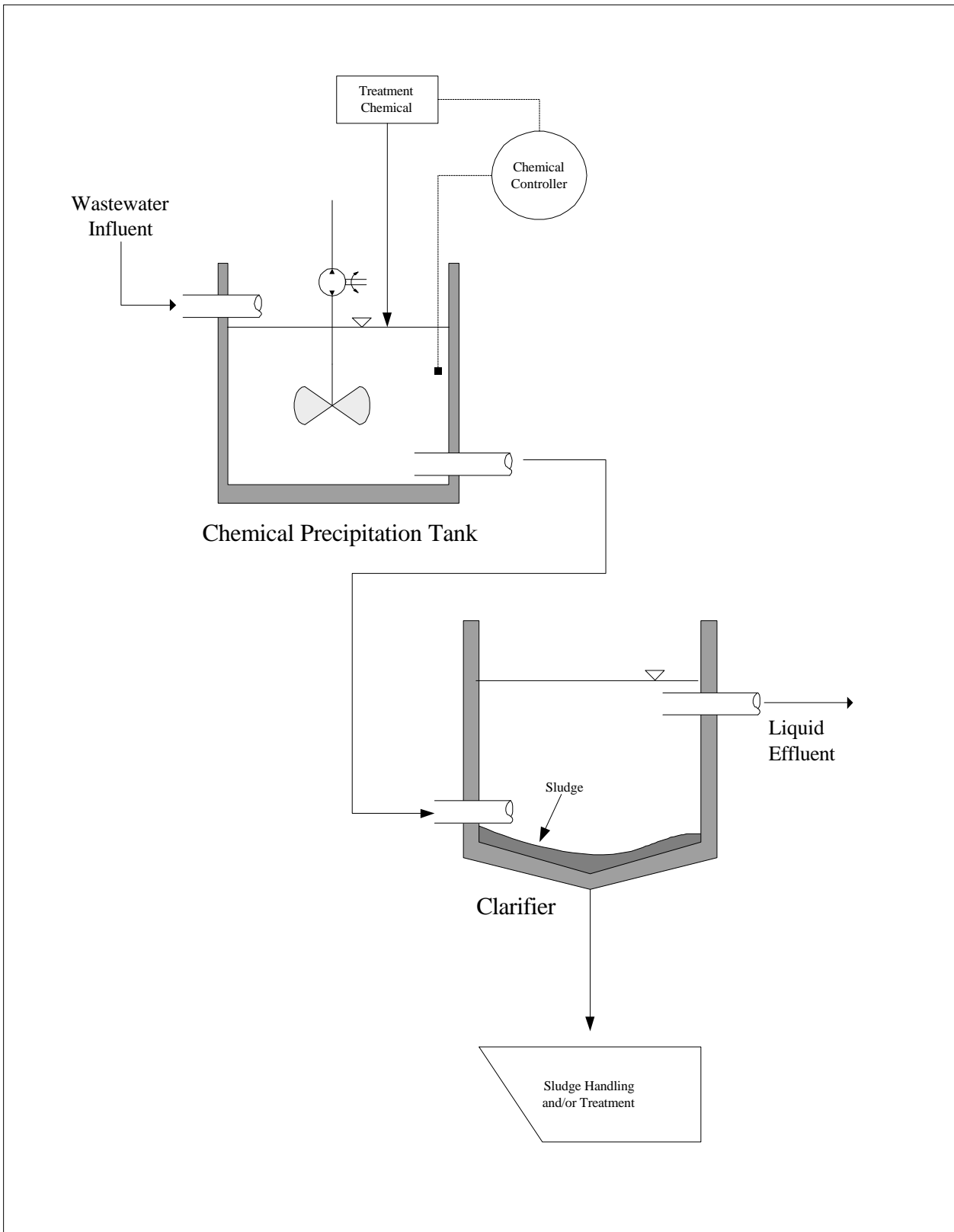
Stripping refers to the removal of pollutant compounds from a wastewater by the passage of air, steam, or other gas, through the liquid. The stripped volatile components are generally condensed and recovered for reuse, disposal, or allowed to be stripped into the atmosphere. If the pollutants are in sufficiently low concentrations, the gaseous phase can be emitted through a stack without treatment.

Air stripping is a process in which air is brought into contact with the liquid. During this contact, the volatile compounds move from the liquid to the gas stream. The process usually takes place in a stripping tower (as shown in Figure 6-5) which consists of a vertical shell filled with packing material to increase the surface area for gas-liquid contact. Usually, the liquid flows down through the stripping column and air passes upward in a counter-current fashion. Another orientation is called "crossflow", where the air is pulled through the sides of the tower along its entire length.

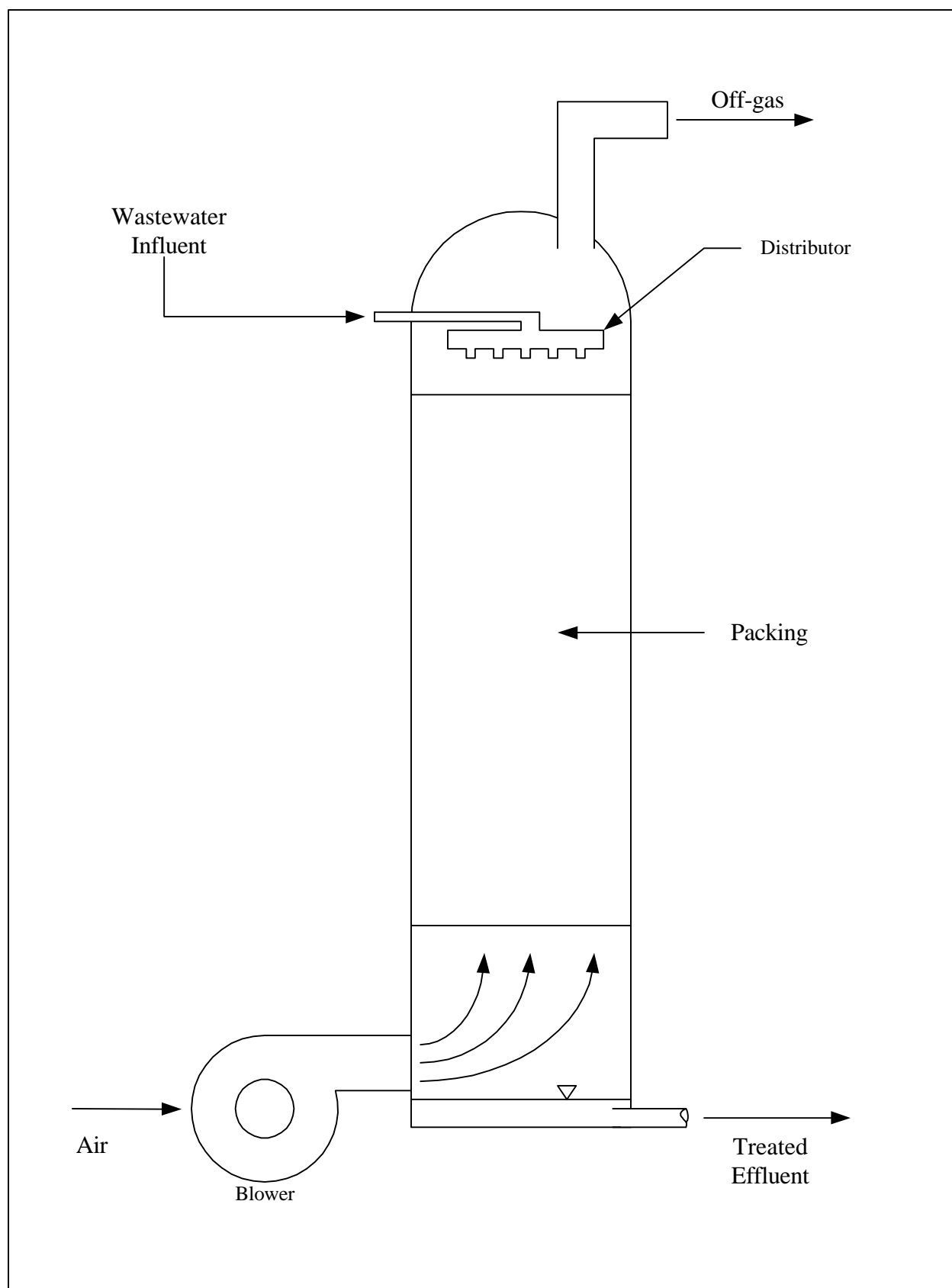
There is only one commercial IWC facility that use air stripping as a treatment option for the removal of excess treatment chemicals contained in its flue gas quench wastewater.

#### **6.1.1.7 Filtration**

Filtration is a method for separating solid particles from wastewaters through the use of a porous medium. The driving force in filtration is a pressure gradient, caused by gravity, centrifugal force, vacuum, or higher than atmospheric pressure. Filtration treatment processes can be used at IWC facilities to remove solids from wastewaters after a chemical precipitation treatment step, or can be used as the primary source of treatment. Filtration processes include a broad range of media and membrane separation technologies from sand filtration to ultrafiltration. To aid in removal, the filter medium may be precoated with a filtration aid such as ground cellulose or diatomaceous earth.



**Figure 6-4. Chemical Precipitation System Design**



**Figure 6-5. Typical Air Stripping System**

Commercial IWC facilities currently have the following types of filtration systems in operation to treat their IWC wastewaters:

<u>Type of Filtration System</u>	<u>Number of Units</u>
Sand	3
Granular multimedia	1
Fabric	1
Ultrafiltration	1

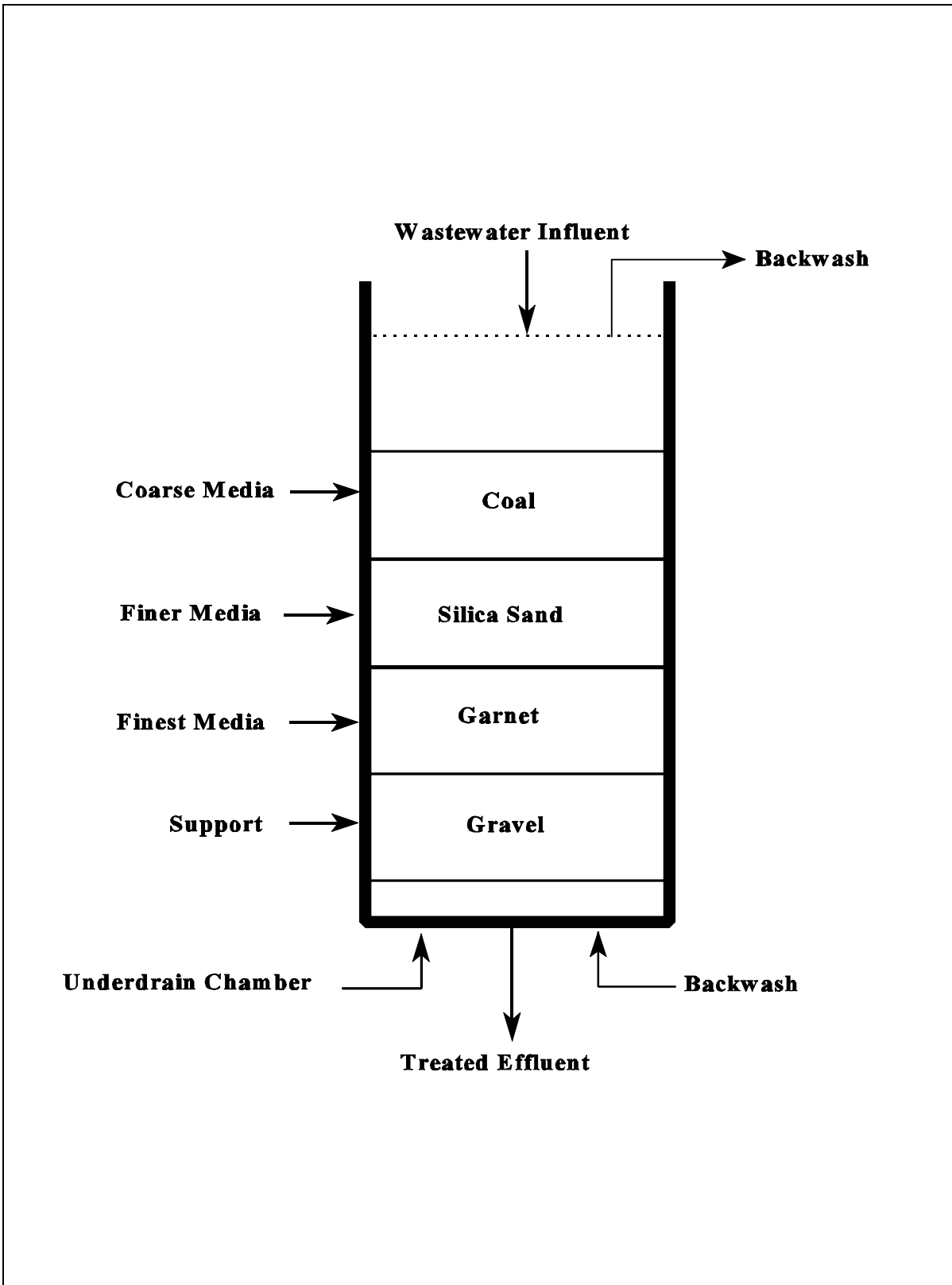
Dissolved compounds in IWC wastewaters can be pretreated by chemical precipitation processes to convert the compound to an insoluble solid particle before filtration. Polymers can be injected into the filter feed piping downstream of feed pumps to enhance flocculation of smaller flocs that may escape an upstream clarifier.

The following paragraphs describe each type of filtration system.

#### **6.1.1.7.1 Sand/Multimedia Filtration**

Granular bed filtration in the IWC industry is used primarily for achieving supplemental removal of residual suspended solids from the effluent of chemical treatment processes, or rarely, as the primary form of wastewater treatment. These filters can be operated either by gravity or in a pressure vessel. In granular bed filtration, the wastewater stream is sent through a bed containing one or more layers of different granular materials. The solids are retained in the voids between the media particles while the wastewater passes through the bed. Typical media used in granular bed filters include anthracite coal, sand, and garnet. These media can be used alone, such as in sand filtration, or in a multimedia combination. Multimedia filters are designed such that the individual layers of media remain fairly discrete. This is accomplished by selecting appropriate filter loading rates, media grain size, and bed density. Hydraulic loading rates for a multi-media filter is between 4 to 10 gpm/sq ft. A typical multimedia filter vessel is shown in Figure 6-6.

The complete filtration process involves two phases: filtration and backwashing. As the filter becomes filled with trapped solids, the efficiency of the filtration process falls off. Head loss is a measure of solids trapped in the filter. As the head loss across the filter bed increases to a limiting



**Figure 6-6: Multimedia Filtration**

value, the end of the filter run is reached and the filter must be backwashed to remove the suspended solids in the bed. During backwashing, the flow through the filter is reversed so that the solids trapped in the media are dislodged and can exit the filter. The bed may also be agitated with air to aid in solids removal. The backwash water is then recycled back into the wastewater feed stream.

#### **6.1.1.7.2 Fabric Filters**

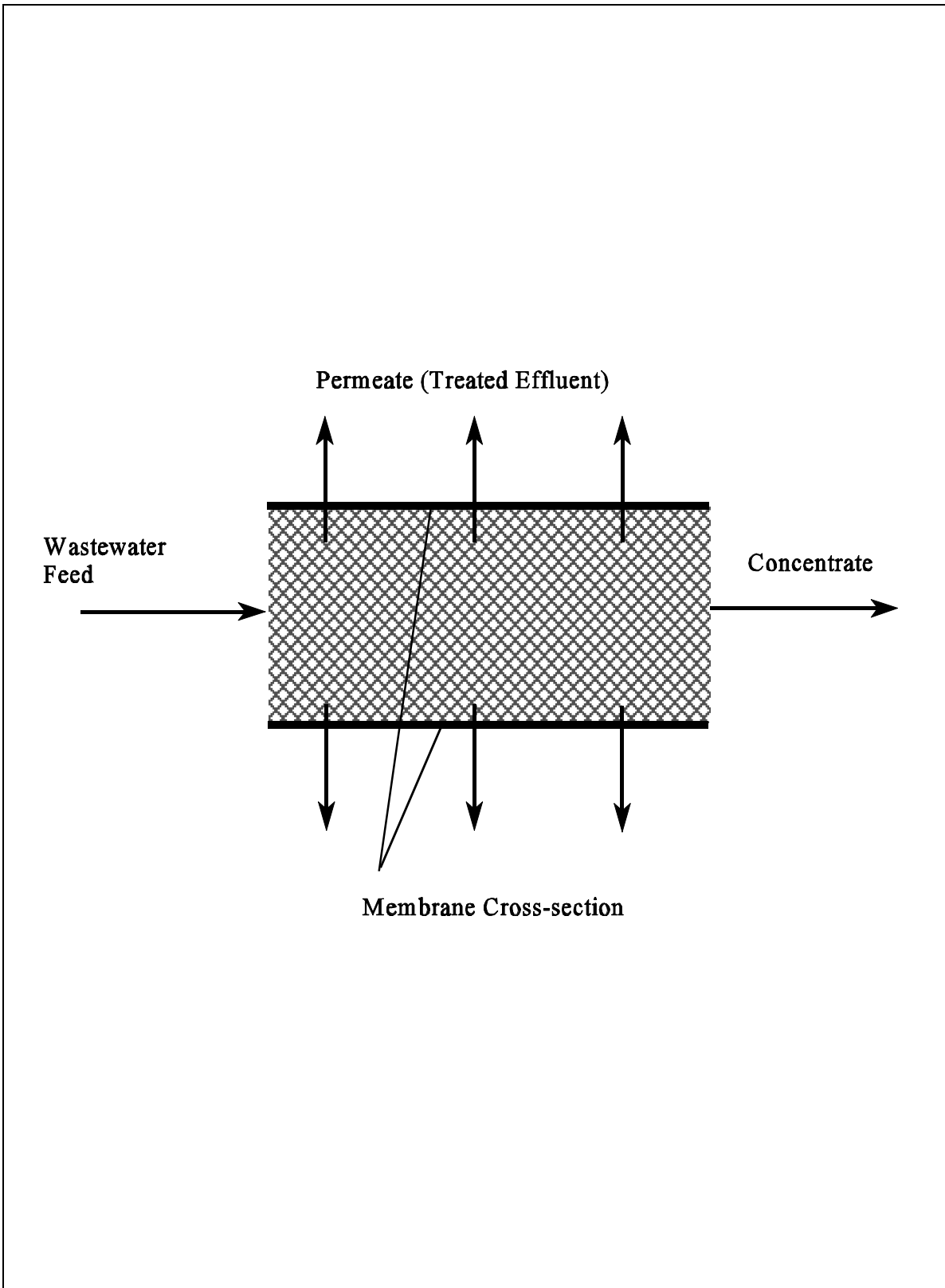
Fabric filters consist of a vessel that contains a cloth or paper barrier through which the wastewater must pass. The suspended matter is screened by the fabric, and the effectiveness of the filter depends on the mesh size of the fabric. Fabric filters may either be backwashed, or built as disposable units.

For waters having less than 10 mg/l suspended solids, cartridge fabric filters may be cost effective. Cartridge filters have very low capital cost and can remove particles of one micron or larger in size. Using two-stage cartridge filters (coarse and fine) in series extends the life of the fine cartridge. Disposable or backwashable bag filters are also available and may be quite cost effective for certain applications. Typically, these fabric filters act as a pre-filter and are used to remove suspended solids prior to other filtrations systems in order to protect membranes and equipment and reduce solids fouling.

#### **6.1.1.7.3 Ultrafiltration**

Ultrafiltration uses a semi-permeable, microporous membrane, through which the wastewater is passed under pressure. Water and low molecular weight solutes, such as salts and surfactants, pass through the membrane and are removed as permeate. Emulsified oils and suspended solids are rejected by the membrane and removed with some of the wastewater as a concentrated liquid. The concentrate is recirculated through the membrane unit until the flow of permeate drops, while the permeate can either be discharged or passed along to another treatment unit. The concentrate is usually stored and held for further treatment or disposal. Several types of ultrafiltration membranes configurations are available: tubular, spiral wound, hollow fiber, and plate and frame. A typical ultrafiltration system is presented in Figure 6-7.





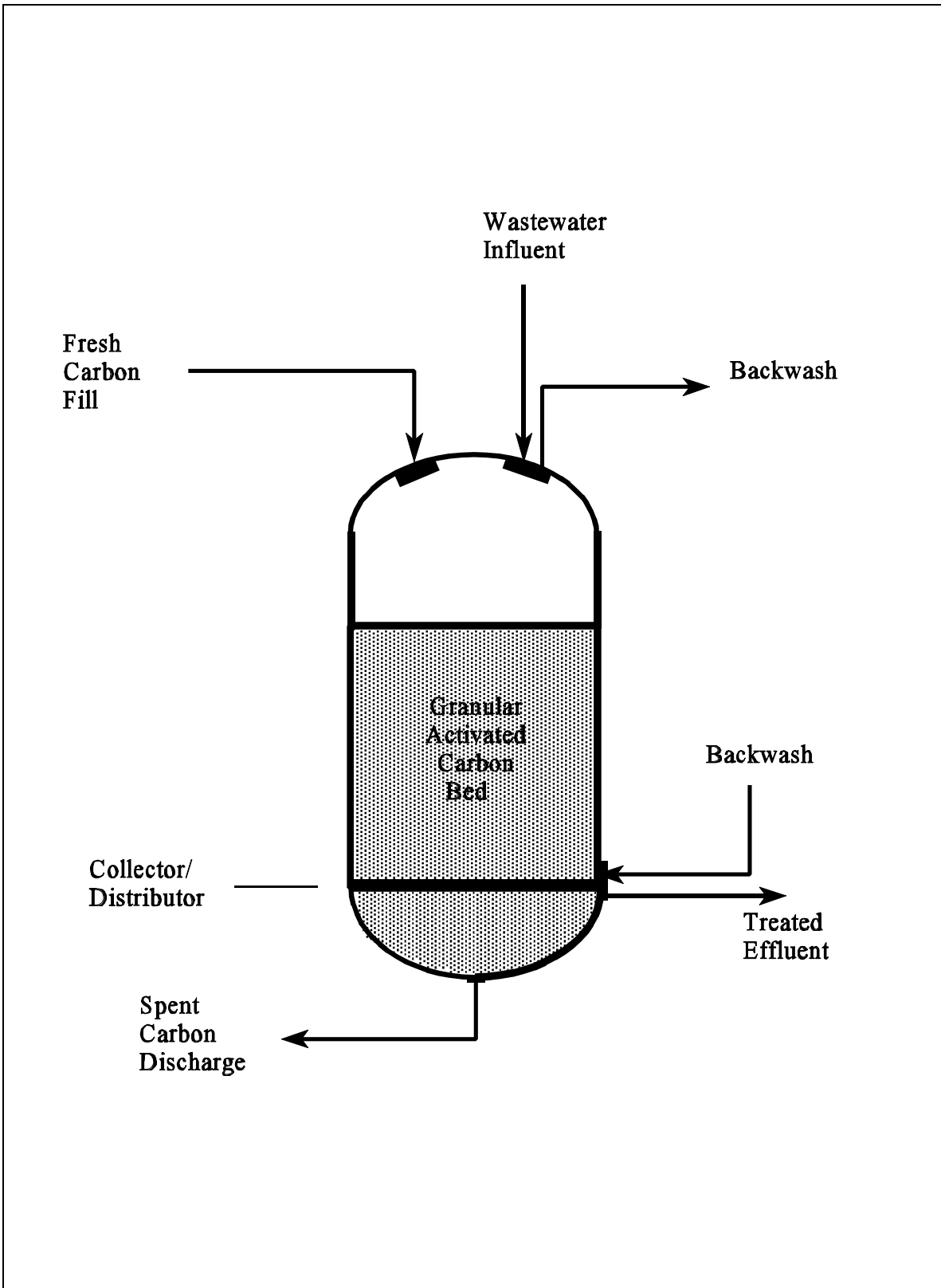
**Figure 6-7. Ultrafiltration System Diagram**

Ultrafiltration in the IWC industry is used for the treatment of metal-bearing wastewaters. It can remove substances with molecular weights greater than 500, including suspended solids, oil and grease, and complexed heavy metals. Ultrafiltration is used when the solute molecules are greater than ten times the size of the solvent molecules, and are less than one-half micron. The primary design consideration in ultrafiltration is the membrane selection. A membrane pore size is chosen based on the size of the contaminant particles targeted for removal. Other design parameters to be considered are the solids concentration, viscosity, and temperature of the feed stream, and the membrane permeability and thickness.

#### **6.1.1.8 Carbon Adsorption**

Granular activated carbon adsorption (GAC) is a physical separation process in which organic and inorganic materials are removed from wastewater by adsorption, attraction, and/or accumulation of the compounds on the surface of the carbon granules. While the primary removal mechanism is adsorption, the activated carbon also acts as a filter for additional pollutant removal. Adsorption capacities of 0.5 to 10 percent by weight are typical. Spent carbon can be regenerated thermally on site by processes such as wet-air oxidation or steam stripping. For smaller operations, spent carbon can be regenerated off site or sent for directly for disposal. Vendors of carbon typically, under contract, exchange spent carbon with fresh carbon.

Activated carbon systems usually consist of a vessel containing a bed of carbon (typically 4 to 12 feet in depth), whereby the wastewater is either passed upflow or downflow through the filter bed. A carbon adsorption vessel is shown in Figure 6-8. Carbon vessels are typically operated under pressure, however some designs use gravity beds. For smaller applications, GAC systems are also available in canister systems which can be readily changed-out and sent for either off-site regeneration or disposal. The key design parameter is the adsorption capacity of the GAC, which is a measure of the mass of contaminant adsorbed per unit mass of carbon, and is a function of the chemical compounds being removed, type of carbon used, and process and operating conditions. The volume of carbon required is based upon the COD of the wastewater to be treated and desired frequency of carbon change-outs. The vessel is typically designed for an empty bed contact time of 15 to 60 minutes. Non-polar, high molecular weight organics with low solubility are readily adsorbed using



**Figure 6-8. Granular Activated Carbon Adsorption**

GAC. Certain organic compounds have a competitive advantage for adsorption onto the GAC, which results in compounds being preferentially adsorbed or causing other less competitive compounds to be desorbed from the GAC. Most organic compounds and some metals typically found in IWC wastewaters are effectively removed using GAC. Two commercial IWC facility employs GAC for treatment of IWC wastewaters.

#### **6.1.1.9 Chromium Reduction**

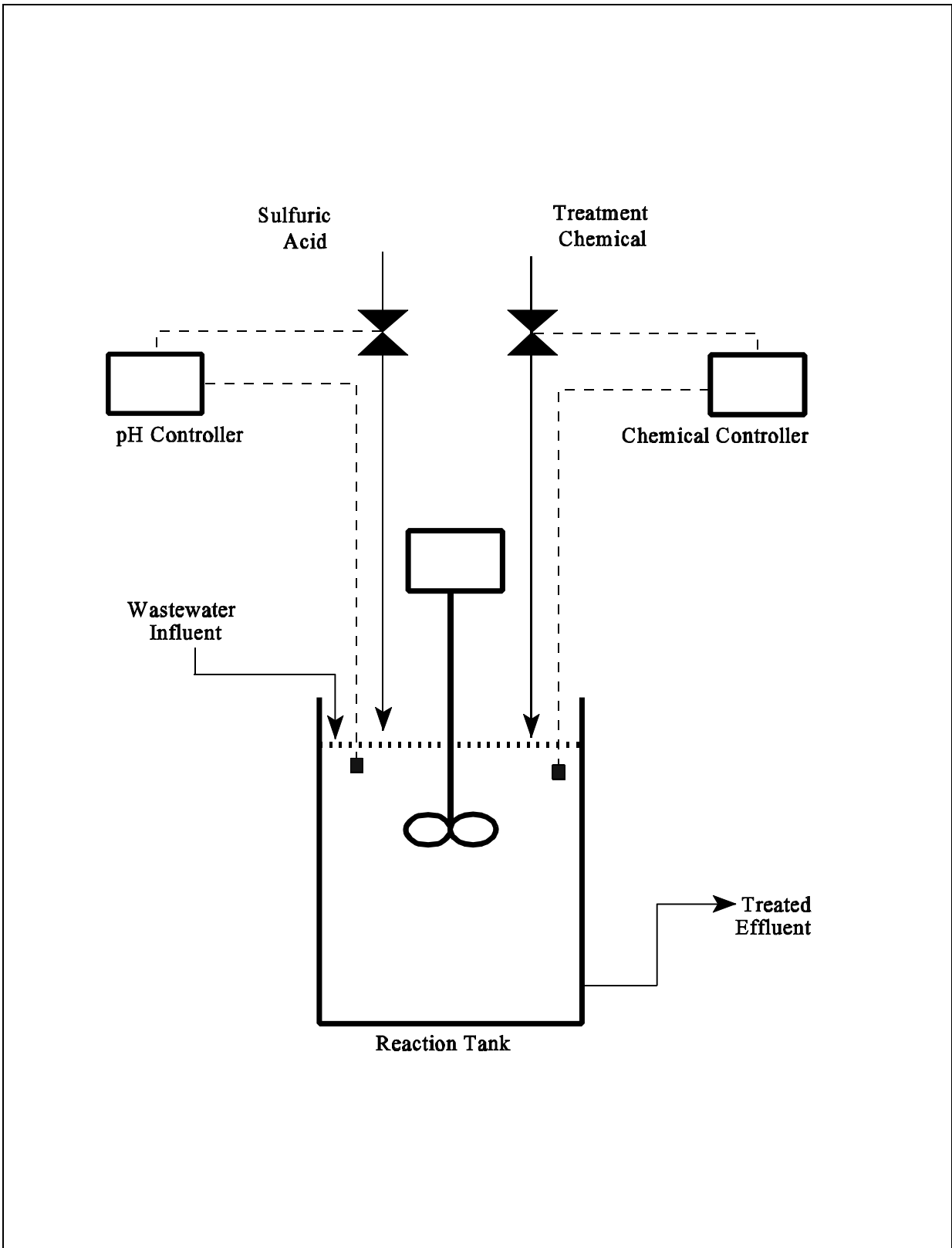
Chemical reduction processes involve a chemical reaction in which electrons are transferred from one chemical to another in order to reduce the chemical state of a contaminant. The main application of chemical reduction in IWC wastewater treatment is the reduction of hexavalent chromium to trivalent chromium. The reduction enables the trivalent chromium to be precipitated from solution in conjunction with other metallic salts. Sodium bisulfate is the reducing agents used by the one commercial IWC facility that incorporates reduction technology for treatment of its IWC wastewater.

Once the chromium has been reduced to the trivalent state, it can be further treated in a chemical precipitation process, where it is removed as a metal hydroxide or sulfide. A typical chromium reduction process is shown in Figure 6-9.

#### **6.1.2 Sludge Handling**

Sludges are generated by a number of treatment technologies, including gravity-assisted separation and filtration. These sludges are further processed at IWC facilities using various methods. Listed below are the number of commercial IWC facilities which employ each type of sludge handling process.

<u>Type of Sludge Handling</u>	<u>Number of Units</u>
Sludge Slurrying	1
Vacuum Filtration	1
Pressure Filtration	7
Centrifuge	1
Dryer	1



**Figure 6-9. Chromium Reduction**

The following paragraphs describe each type of sludge handling system.

#### **6.1.2.1 Sludge Slurrying**

Sludge slurrying is the process of transporting sludge from one treatment process to another. It can only be applied to liquid sludges that can be pumped through a pipe under pressure. Only one commercial IWC facility utilizes a sludge slurry process.

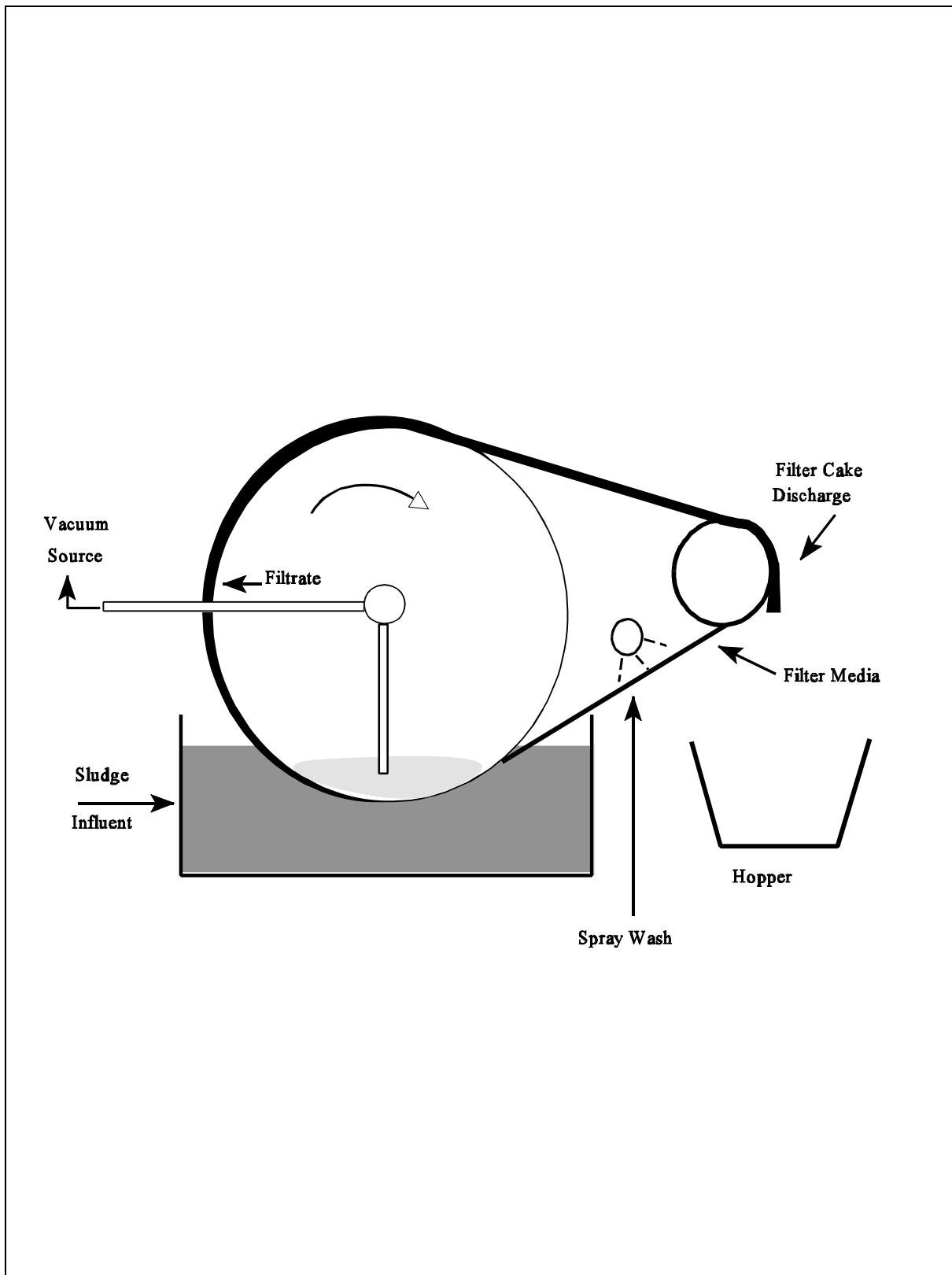
#### **6.1.2.2 Vacuum Filtration**

A typical vacuum filtration unit is shown in Figure 6-10. Vacuum filtration provides more aggressive sludge drying by placing the sludge on a screen or mesh and drawing a vacuum through the screen, which draws the liquid out of the sludge. Often the screen is oriented on a cylindrical support, which rotates. The sludge is distributed over the cylinder as it rotates. As the screen rotates, the dried sludge is removed with a scraper, and collected in a hopper placed below the filtration unit. These units can dry sludges to approximately 30 to 50 percent solids. Only one commercial IWC facility utilizes vacuum filtration for sludge dewatering.

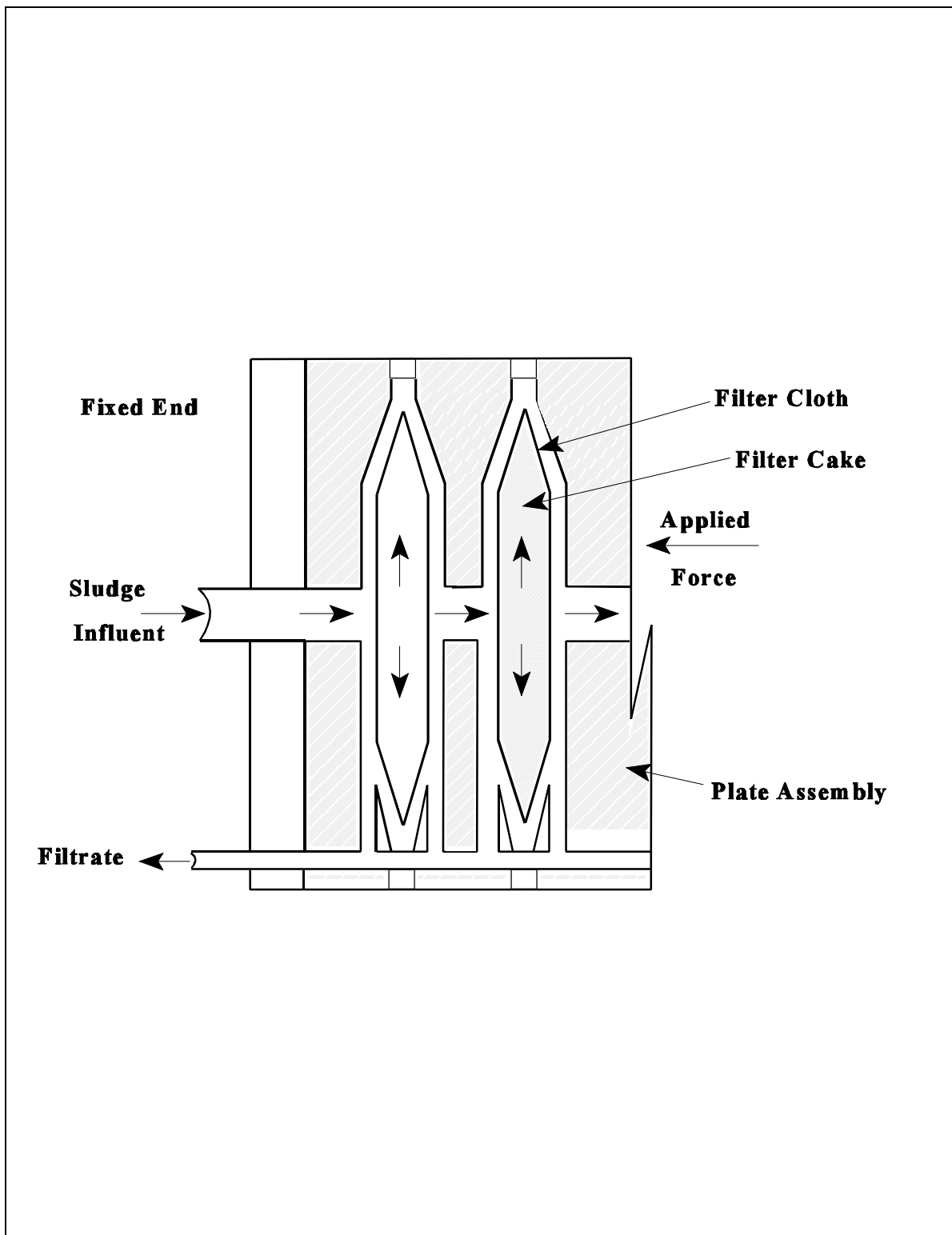
#### **6.1.2.3 Pressure Filtration**

The plate and frame pressure filtration system is the most common process used by the IWC industry to dewater sludges from physical/chemical treatment processes. Seven commercial IWC facilities use a plate and frame pressure filtration system to dewater sludge. Sludges generated by IWC wastewater treatment processes are typically 2 to 5 percent solids by weight. These sludges are then dewatered to a 30 to 50 percent solids by weight using a plate and frame filter. Sludges from treatment systems can be thickened by gravity or stabilized prior to dewatering, or may be processed directly with the plate and frame pressure filtration unit.

A pressure filter consists of a series of screens (see Figure 6-11) upon which the sludge is applied under pressure. A precoat material may be applied to the screens to aid in solids removal. The applied pressure forces the liquid through the screen, leaving the solids to accumulate behind the screen. Filtrate which passes through the screen media is typically recirculated back to the head of



**Figure 6-10. Vacuum Filtration**



**Figure 6-11: Plate and Frame Pressure Filtration System Diagram**



the on-site wastewater treatment plant. Screens (also referred to as plates) are held by frames placed side by side and held together with a vice-type mechanism. The unit processes sludge until all of the plates are filled with dry sludge as indicated by a marked rise in the application pressure. Afterwards, the vice holding the plates is loosened and the frames separated. Dried sludge is manually scraped from the plates and collected in a hopper for final disposal. The size of the filter and the number of plates utilized depends not only on the amount of solids produced by treatment processes, but also is highly dependent on the desired operational requirements for the filter (e.g., shifts per day). A plate and frame pressure filter can produce a sludge with a higher solids content than most other methods of sludge dewatering. Pressure filters offer operational flexibility since they are typically operated in a batch mode.

#### **6.1.2.4 Centrifuges**

Centrifuges use centripetal force to separate the liquid from the sludge solids. The sludge enters the top of a rapidly spinning cylinder where the solids are "thrown" to the outer wall of the vessel. The separated solids are continually removed through an orifice on the outer wall, and the liquid stream is collected at the bottom.

Because the unit is spinning rapidly, and sludge often contains abrasive materials, centrifuges often require a high level of maintenance. Centrifuges typically dry sludges to the range of 20 to 30 percent solids by weight. Only one commercial IWC facility utilizes a centrifuges for sludge dewatering.

#### **6.1.2.5 Dryer**

One commercial IWC facility employs a sludge dryer to remove the moisture from its sludge prior to disposal of the solid waste. The sludge dryer uses thermal energy derived from steam or electricity to evaporate the moisture from the sludge in a drying bed/tank.

### **6.1.3            *Zero Discharge Options***

Some IWC facilities use treatment and disposal practices that result in no discharge of IWC wastewaters to surface waters. These practices are described below.

#### **6.1.3.1            *Incineration***

Two commercial IWC facilities generate annual flow rates of 108,100 and 300,000 gallons and dispose of their IWC wastewater exclusively by incinerating them on site. Normally, these wastewater flows are minimal compared to the amount of fuel and/or waste the thermal unit handles, and as such, these IWC facilities find it cheaper to dispose of their wastewaters in this fashion rather than utilizing other disposal methods.

#### **6.1.3.2            *Off-Site Disposal***

Three commercial IWC facilities transport their wastewater off site to either another IWC facility's wastewater treatment system or to a Centralized Wastewater Treatment (CWT) facility for ultimate disposal. These three facilities generate annual flow rates of 18,250 gallons, 10,000 gallons, and 43 million gallons. A fourth facility with an annual flow rate of 4.865 million gallons sells their wastewater as oil well completion fluid.

#### **6.1.3.3            *Evaporation/Land Applied***

One commercial IWC facility with an annual flow rate of approximately 100 million gallons discharges its IWC wastewater into on-site surface impoundments as a means of ultimate disposal. There is no discharge to a receiving water from these impoundments. Rather, water is lost by evaporation.

### **6.2                *TREATMENT OPTIONS FOR OTHER WASTEWATERS GENERATED BY IWC OPERATIONS***

Commercial IWC facilities employ the same two treatment options (physical/chemical treatment or zero discharge) to treat other wastewaters generated as a result of IWC operations (see

Section 4). Most of the same treatment technologies are used to treat these secondary wastewaters as are being used to treat IWC wastewaters. The EPA's Section 308 Questionnaire obtained information on eight different technologies currently in use by 39 commercial IWC facilities for the treatment of various wash down waters, run-off from IWC areas, and laboratory wastewater. A breakdown of these treatment systems is shown below:

<u>Treatment technology</u>	<u>Number of commercial IWC facilities</u>
Equalization	8
Neutralization	9
Flocculation	6
Gravity Assisted Separation	8
Chemical Precipitation	6
Air Stripping	1
Carbon Adsorption	5
Chemical Oxidation	3
Sludge Handling	11

Each of the above treatment technologies, with the exception of chemical oxidation, has been previously described in Section 6.1. As for IWC wastewaters, the design and operation of these treatment systems to treat other wastewaters generated by IWC operations are the same. Since the amount of wastewater generated by other IWC operations is minimal as compared to IWC wastewater flow rates, these small flows are typically mixed with IWC wastewaters for treatment in the physical/chemical treatment system. Below is a description of the only new treatment technology listed above that was not described in the previous section: chemical oxidation.

### **6.2.1            *Chemical Oxidation***

Chemical oxidation treatment processes may be used to remove ammonia, to reduce the concentration of residual organics, and to reduce the bacterial and viral content of wastewaters. IWC facilities that use chemical oxidation processes use them for the treatment of other out-of-scope wastewaters generated at these facilities, such as landfill leachate, storm water, groundwater, or sanitary wastewater. Both chlorine and ozone can be used to destroy some residual organics in

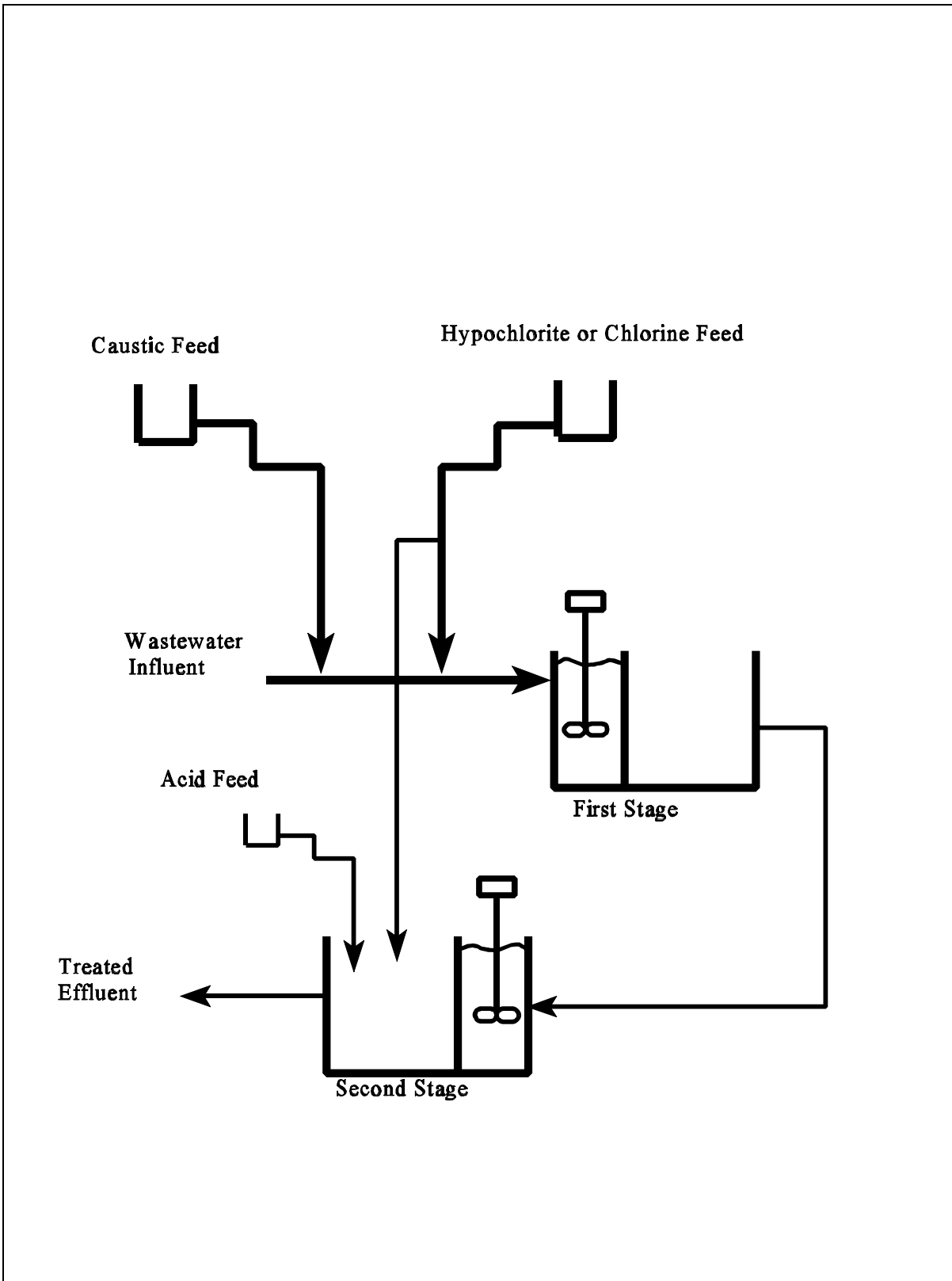
wastewater. When these chemicals are used for this purpose, disinfection of the wastewater is usually an added benefit. A further benefit of using ozone is the removal of color. Ozone can also be combined with hydrogen peroxide for removing organic compounds in contaminated wastewater. Oxidation is also used to convert pollutants to terminal end products or to intermediate products that are more readily biodegradable or more readily removed by adsorption. There are three commercial IWC facilities that use chemical oxidation units as part of their treatment process to treat secondary IWC wastewaters.

Chemical oxidation is a chemical reaction process in which one or more electrons are transferred from the chemical being oxidized to the chemical initiating the transfer (the oxidizing agent). The electron acceptor may be another element, including an oxygen molecule, or it may be a chemical species containing oxygen, such as hydrogen peroxide and chlorine dioxide or some other electron acceptor. This process is also effective in destroying cyanide and toxic organic compounds. Figure 6-12 illustrates one such chemical oxidation process. According to the Section 308 Questionnaire data, IWC facilities use chemical oxidation processes to treat organic pollutants and as a disinfectant. When treating organic wastes, these processes use oxidizing chemicals, such as hydrogen peroxide, or ozone. As a disinfection process, an oxidant (usually chlorine) is added to the wastewater in the form of either chlorine dioxide or sodium hypochlorite. Other disinfectant chemicals include ozone, peroxide, and calcium hypochlorite. Once the oxidant is mixed with the wastewater, sufficient detention time is allowed (usually 30 minutes) for the disinfecting reactions to occur.

### **6.2.2            *Zero Discharge Options***

Other IWC facilities use treatment and disposal practices that result in no discharge of their secondary IWC wastewaters to surface waters. A breakdown of the zero discharge options for secondary IWC wastewaters at commercial IWC facilities is as follows:

<u>Zero discharge option</u>	<u>Number of commercial IWC facilities</u>
Incineration	2
Off-site disposal	5



**Figure 6-12. Cyanide Destruction**

Evaporated/land applied	2
Recycled	3
Deep well disposal	2

Most of the above zero discharge options, with the exception of deep well disposal, have been described previously in section 6.1.3. Below is a description of the only new zero discharge option listed above that was not described in the previous section; deep well disposal.

#### **6.2.2.1 Deep Well Disposal**

Deep well disposal consists of pumping the wastewater into a disposal well which discharges the liquid into a deep aquifer. These aquifers do not typically contain potable water and commonly are brackish. These aquifers are thoroughly characterized to insure that they are not hydrogeologically connected to an aquifer which is or has the potential to be used for potable water. Characterization confirms the existence of impervious layers of rock above and below the aquifer in order to prevent the migration of pollutants.

### **6.3 *OTHER ON-SITE WASTEWATER TREATMENT TECHNOLOGIES***

There are other treatment technologies used by commercial IWC facilities to treat other on-site wastewaters (leachates, sanitary wastewater). Some facilities may use one or more of the technologies described above for the treatment of these wastewaters. Four commercial IWC facilities use some form of biological treatment as the preferred method of treatment of leachates and other organic wastewaters. The biological treatment technologies used at these IWC facilities are listed below:

<u>Treatment technology</u>	<u>Number of Facilities</u>
Activated sludge	1
Trickling filter	1
PAC system (powdered activated carbon)	2

## **6.4                    *TREATMENT PERFORMANCE AND DEVELOPMENT OF REGULATORY OPTIONS***

This section presents an evaluation of performance data on treatment systems collected by EPA during field sampling programs and the rationale used in the development of the proposed regulatory options.

### **6.4.1                *Performance of EPA Sampled Treatment Processes***

To collect data on potential BAT treatment technologies, Questionnaire responses were reviewed to identify candidate facilities that had well operated and designed wastewater treatment systems. EPA conducted site visits to 13 IWC facilities to evaluate treatment systems; based on these site visits, three facilities were selected for a five consecutive day sampling episode (Episode ID #s 4646, 4671, and 4733). At these facilities, EPA collected data on a variety of physical and chemical treatment processes. Technologies evaluated at the selected sampling facilities include hydroxide precipitation, sulfide precipitation, sedimentation, carbon adsorption, sand filtration and ultrafiltration. Table 6-1 presents a summary of the treatment technologies sampled during each EPA sampling episode. Summaries of the treatment system performance data collected by EPA during each of these sampling episodes are presented below.

#### **6.4.1.1            *Treatment Performance for Episode #4646***

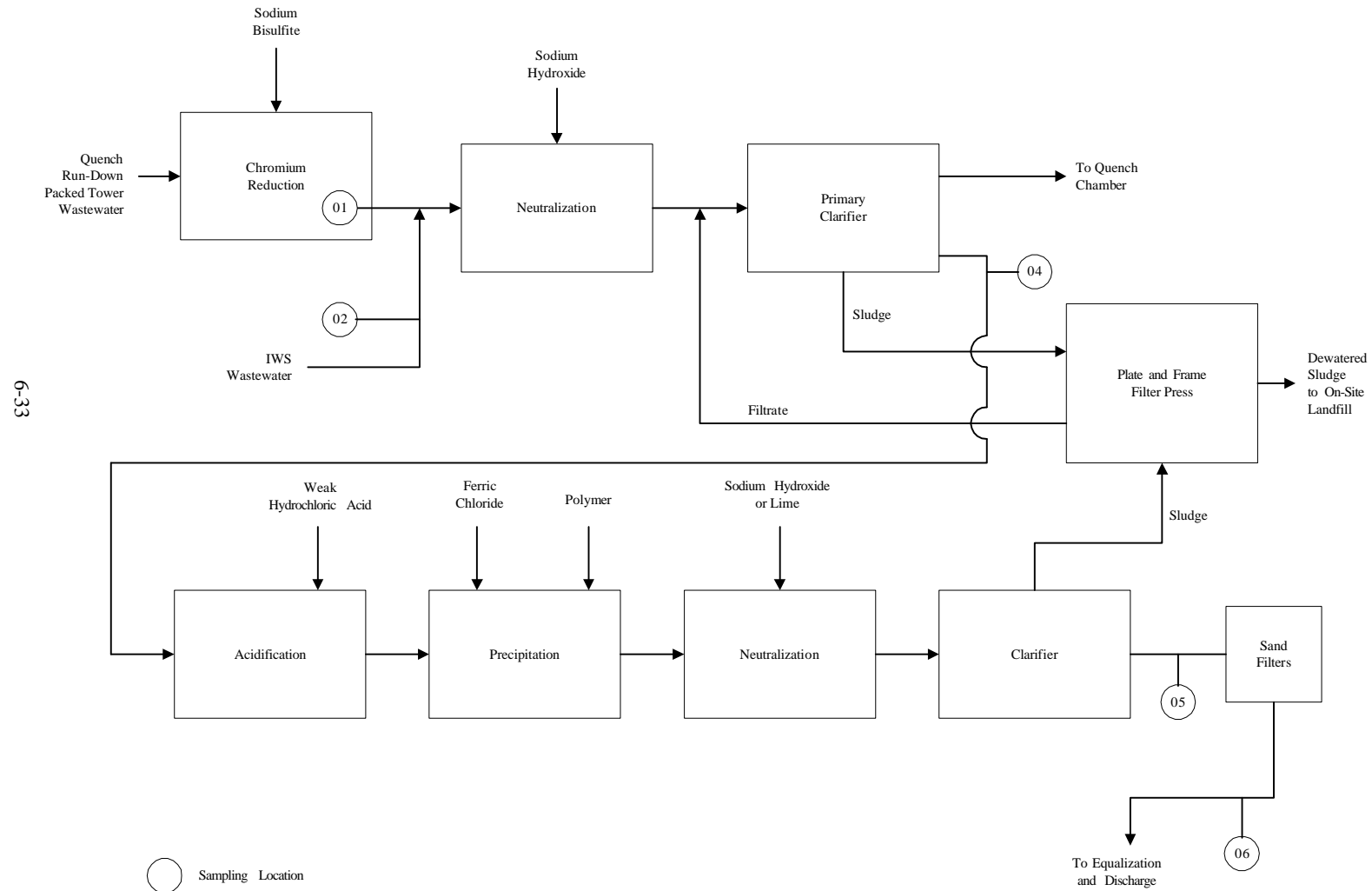
EPA performed a week-long sampling program, episode # 4646. This facility was evaluated by EPA in order to obtain performance data on several treatment technologies installed at this facility including hydroxide precipitation, ferric chloride precipitation, and sand filtration. A flow diagram of the IWC wastewater treatment system sampled during episode # 4626 is presented in Figure 6-13. The wastewater treatment system used at this IWC facility treats wastewater from the air pollution control system (quench chamber run-down and packed tower wastewater) and the ionizing wet scrubber. The wastewater treatment system is comprised of two separate systems both of which were sampled by EPA. The primary system is part of the primary water circulation loop that serves the incinerator and consists of chromium reduction and hydroxide precipitation treatment followed by

**Table 6-1. Description of IWC Sampling Episodes**

<b>Episode</b>	<b>Influent Sample Point</b>	<b>Effluent Sample Point</b>	<b>Description</b>
4646	1+2	4	First-stage chemical precipitation using sodium hydroxide
	4	5	Second-stage chemical precipitation using ferric chloride
	5	6	Sand filtration
	1+2	6	Overall treatment system- first-stage chemical precipitation, second-stage chemical precipitation, and sand filter
4671	1	2	First-stage chemical precipitation using sodium hydroxide
	2	3	Second-stage chemical precipitation using sodium hydroxide and ultrafiltration
	1	3	Overall treatment system- first-stage chemical precipitation,second-stage chemical precipitation, and ultrafiltration
4733	1	2	Sulfide precipitation and Lancy filters
	2	4	Carbon adsorption system
	1	4	Overall treatment system- sulfide precipitation, Lancy filters and carbon adsorption system



**Figure 6-13. EPA Sampling Episode 4646 - IWC Wastewater Treatment System Block Flow Diagram with Sampling Locations**



sedimentation. Only the precipitation portion of the primary system was sampled by EPA. Blowdown from the primary loop is treated in the secondary system. Treatment in the secondary loop consists of precipitation using ferric chloride followed by sedimentation and sand filtration. Table 6-2 presents a summary of percent removal data collected at episode #4646 for the performance of the entire treatment system, both the primary and secondary system, as well as the primary system, secondary system, and sand filter separately. Percent removal efficiencies for the processes were calculated by first obtaining an average concentration based upon the daily sampling results for each sample collection location (influent and effluent point to the treatment process). Next, the percent removal efficiency of the system was calculated using the following equation:

$$\text{Percent Removal} = \frac{[\text{Concentration Influent} - \text{Concentration Effluent}]}{\text{Concentration Influent}} \times 100$$

Negative percent removals for a treatment process were reported on the table as “0.0” percent removals.

The treatment efficiency of the primary system was assessed using the data obtained from sampling points 01, 02, and 04 (see Figure 6-13). Influent concentration data was obtained using a flow-weighted average for sample points 01 and 02. Effluent from the primary treatment system was represented by sample point 04. As demonstrated on the Table 6-2, the primary treatment system experienced good overall removals for TSS (90.9 percent). COD was removed at 70.9 percent, whereas, no removal was observed for TDS. Many of the metals observed in the influent were removed to high levels; these include aluminum, cadmium, chromium, copper, iron, lead, tin, titanium, and zinc. Other metals also with limited removals include manganese (66.5 percent), mercury (63.9 percent), silver (40.3 percent), and strontium (19.7 percent). Poor removal efficiencies were observed for in the primary system for antimony, arsenic, boron, molybdenum, and selenium.

The treatment efficiency of the secondary system was assessed using the data obtained from sampling points 04 and 05 (see Figure 6-13). Influent concentration data to the secondary system was obtained using sampling point 04 which is also the effluent from the primary system. Effluent from the secondary treatment system was represented by sample point 05. As demonstrated on the

Table 6-2. Treatment Technology Performance for Facility 4646

		First Stage Chemical Precipitation Sample Points 1+2 to 4						Second Stage Chemical Precipitation Sample Points 4 to 5					
Pollutant of Interest	CAS #	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal
<b>Conventional</b>													
TSS	C-009	4,000	01+02	122,560	04	11,200	90.9	4,000	04	11,200	05	13,400	0.0
<b>Non-Conventional</b>													
COD	C-004	5,000	01+02	535,920	04	156,200	70.9	5,000	04	156,200	05	238,800	0.0
TDS	C-010		01+02	30,694,160	04	50,320,000	0.0		04	50,320,000	05	36,910,000	26.6
<b>Metals</b>													
Aluminum	7429905	200	01+02	1,104	04	170	84.6	200	04	170	05	197	0.0
Antimony	7440360	20.0	01+02	672	04	1,026	0.0	20.0	04	1,026	05	381	62.9
Arsenic	7440382	10.0	01+02	475	04	494	0.0	10.0	04	494	05	8.8	98.2
Boron	7440428	100	01+02	1,280	04	1,744	0.0	100	04	1,744	05	1,705	2.2
Cadmium	7440439	5.0	01+02	929	04	174	81.2	5.0	04	174	05	47.2	72.9
Chromium	7440473	10.0	01+02	220	04	53.4	75.8	10.0	04	53.4	05	ND	81.3
Copper	7440508	25.0	01+02	5,228	04	321	93.9	25.0	04	321	05	18.8	94.2
Iron	7439896	100	01+02	7,066	04	254	96.4	100	04	254	05	1,994	0.0
Lead	7439921	50.0	01+02	4,691	04	117	97.5	50.0	04	117	05	47.7	59.1
Manganese	7439965	15.0	01+02	228	04	76.6	66.5	15.0	04	76.6	05	517	0.0
Mercury	7439976	0.2	01+02	59.2	04	21.4	63.9	0.2	04	21.4	05	2.6	87.7
Molybdenum	7439987	10.0	01+02	936	04	1,137	0.0	10.0	04	1,137	05	578	49.1
Selenium	7782492	5.0	01+02	240	04	263	0.0	5.0	04	263	05	49.6	81.1
Silver	7440224	10.0	01+02	283	04	169	40.3	10.0	04	169	05	9.5	94.4
Strontium	7440246	100	01+02	408	04	328	19.7	100	04	328	05	689	0.0
Tin	7440315	30.0	01+02	1,882	04	45.9	97.6	30.0	04	45.9	05	33.0	28.2
Titanium	7440326	5.0	01+02	2,116	04	32.9	98.4	5.0	04	32.9	05	3.9	88.2
Zinc	7440666	20.0	01+02	9,456	04	209	97.8	20.0	04	209	05	121	42.2
<b>Pesticides/Herbicides</b>													
Dichloroprop	120365	1.0	01+02	3.1	04	NS	NS	1.0	04	NS	05	NS	NS
MCPP	7085190	50.0	01+02	1,027	04	NS	NS	50.0	04	NS	05	NS	NS

Negative percent removal are recorded as 0.0.

NS: Not Sampled

ND: Non-detect

DL: Specific detection limits of sample when there is a non-detect, otherwise it is the method detection limitSP: Sample point.

Table 6-2 con't. Treatment Technology Performance for Facility 4646

		Sand Filtration Sample Points 5 to 6						Entire Treatment System Sample Points 1+2 to 6					
Pollutant of Interest	CAS #	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal
<b>Conventional</b>													
TSS	C-009	4,000	05	13,400	06	5,500	59.0	4,000	01+02	122,560	06	5,500	95.5
<b>Non-Conventional</b>													
COD	C-004	5,000	05	238,800	06	257,900	0.0	5,000	01+02	535,920	06	257,900	51.9
TDS	C-010		05	36,910,000	06	38,150,000	0.0		01+02	30,694,160	06	38,150,000	0.0
<b>Metals</b>													
Aluminum	7429905	200	05	197	06	160	18.4	200	01+02	1,104	06	160	85.5
Antimony	7440360	20.0	05	381	06	346	9.3	20.0	01+02	672	06	346	48.5
Arsenic	7440382	10.0	05	8.8	06	8.1	8.1	10.0	01+02	475	06	8.1	98.3
Boron	7440428	100	05	1,705	06	1,731	0.0	100	01+02	1,280	06	1,731	0.0
Cadmium	7440439	5.0	05	47.2	06	19.9	57.7	5.0	01+02	929	06	19.9	97.9
Chromium	7440473	10.0	05	ND	06	ND	0.0	10.0	01+02	220	06	ND	95.5`
Copper	7440508	25.0	05	18.8	06	10.1	46.1	25.0	01+02	5,228	06	10.1	99.8
Iron	7439896	100	05	1,994	06	128	93.6	100	01+02	7,066	06	128	98.2
Lead	7439921	46.8	05	47.7	06	ND	1.8	46.8	01+02	4,691	06	ND	99.0
Manganese	7439965	15.0	05	517	06	545	0.0	15.0	01+02	228	06	545	0.0
Mercury	7439976	2.0	05	2.6	06	ND	24.2	2.0	01+02	59.2	06	ND	96.6
Molybdenum	7439987	10.0	05	578	06	580	0.0	10.0	01+02	936	06	580	38.0
Selenium	7782492	5.0	05	49.6	06	26.0	47.5	5.0	01+02	240	06	26.0	89.1
Silver	7440224	5.0	05	9.5	06	ND	47.3	5.0	01+02	283	06	ND	98.2
Strontium	7440246	100	05	689	06	674	2.1	100	01+02	408	06	674	0.0
Tin	7440315	30.0	05	33.0	06	31.5	4.5	30.0	01+02	1,882	06	31.5	98.3
Titanium	7440326	5.0	05	3.9	06	6.8	0.0	5.0	01+02	2,116	06	6.8	99.7
Zinc	7440666	20.0	05	121	06	24.2	80.0	20.0	01+02	9,456	06	24.2	99.7
<b>Pesticides/Herbicides</b>													
Dichloroprop	120365	1.0	05	NS	06	ND	NS	1.0	01+02	3.1	06	ND	67.3
MCPP	7085190	50.0	05	NS	06	1,482	NS	50.0	01+02	1,027	06	1,482	0.0

Negative percent removal are recorded as 0.0.

NS: Not Sampled

ND: Non-detect

DL: Specific detection limits of sample when there is a non-detect, otherwise it is the method detection limit

SP: Sample point.

Table 6-2, the secondary treatment system experienced no additional removals for TSS or COD. As in the primary system, no removal was observed for TDS. For those metals for which there was little or no removal in the primary system, improved removals were generally observed in the second system. These metals include antimony (62.9 percent), arsenic (98.2 percent), selenium (81.1 percent), and silver (94.4 percent). Other metals for which adequate removals were observed in the primary system also experienced additional removals in the secondary system. The data show the following removals: cadmium (72.9 percent), chromium (81.3 percent), copper (94.2 percent), mercury (87.7 percent), and titanium (88.2 percent).

The treatment efficiency of the sand filter was evaluated using the data obtained from sampling points 05 and 06 (see Figure 6-13). Influent concentration data was obtained using sample point 05 which represents the discharge from the secondary treatment system. Effluent from the sand filter, as well as, the overall effluent from the treatment process was represented by sample point 06. As demonstrated on the Table 6-2, the treatment system achieved a removal rate for TSS of 59.0 percent. No removals were observed for COD or TDS. Additional metals were removed by the sand filter including cadmium, copper, iron, selenium, silver, and zinc. Limited additional removals were also observed for aluminum and mercury.

The treatment efficiency of the entire treatment system was evaluated using the data obtained from sampling points 01, 02, and 06 (see Figure 6-13). Influent concentration data was obtained using a flow-weighted average for sample points 01 and 02. Effluent from the treatment system was represented by sample point 06. As demonstrated on the Table 6-2, the treatment system achieved good overall removal for TSS (95.5 percent). COD was removed at 51.9 percent, whereas, no removal was observed for TDS. Many of the metals observed in the influent were removed to levels exceeding 95 percent removal. These include arsenic, cadmium, chromium, copper, iron, lead, mercury, silver, tin, titanium, and zinc. Other metals also with high removals include aluminum (85.5 percent) and selenium (89.1 percent). Overall poor removal efficiencies were observed for antimony (48.5 percent) and molybdenum (38.0 percent). No removals were observed for the treatment system for boron, manganese, and strontium. Dichloroprop, a pesticide parameter, was detected in the influent in low levels and was not detected in the effluent. MCPPE did not experience any removal through the treatment system.

#### **6.4.1.2 Treatment Performance for Episode #4671**

EPA performed a week-long sampling program, episode #4671. This facility was evaluated by EPA to obtain performance data on various treatment units which are in operation at this facility, including a combination sulfide and hydroxide precipitation process, conventional hydroxide precipitation, and ultrafiltration. A flow diagram of the IWC wastewater treatment system sampled during episode # 4671 is presented in Figure 6-14. The wastewater treatment system used at this IWC facility treats wastewater from the air pollution control system. The air pollution control system consists of a quench tank, packed tower, and a venturi scrubber. The wastewater treatment system is comprised of two separate systems both of which were sampled by EPA. The primary system is part of the primary water circulation loop that serves the incinerator. Treatment processes for the primary system consists of sulfide precipitation using ferrous sulfate followed by hydroxide precipitation using sodium hydroxide and lime and then followed by sedimentation. The facility treats the discharge from the primary loop in the secondary system. Treatment in the secondary loop consists of hydroxide precipitation using sodium hydroxide followed by sedimentation and ultrafiltration. Table 6-3 presents a summary of percent removal data collected at episode #4671 for the performance of the entire treatment system, both the primary and secondary system, and for the primary system only.

The treatment efficiency of the primary treatment system was evaluated using the data obtained from sampling points 01 and 02 (see Figure 6-14). Influent concentration data for the primary system was obtained using sample point 01. Effluent from the primary treatment system was represented by sample point 02. As demonstrated on Table 6-3, the primary treatment system removal rate for TSS was 70.6 percent. COD was removed at 12.3 percent, whereas, TDS was removed at 7.8 percent. Metals with high removal rates in the primary system include: aluminum (83.1 percent), chromium (97.4 percent), copper (72.0 percent), iron (93.4 percent), lead (90.4 percent), and titanium (95.1 percent). The system achieved limited removals for other metals through the primary system. These include boron, cadmium, manganese, mercury, tin, and zinc. Poor to no removals were observed for antimony, arsenic, molybdenum, silver, and strontium. However, influent concentrations to the primary treatment system for some metals, such as arsenic, cadmium,

**Figure 6-14. EPA Sampling Episode 4671 - IWC Wastewater Treatment System Block Flow Diagram with Sampling Locations**

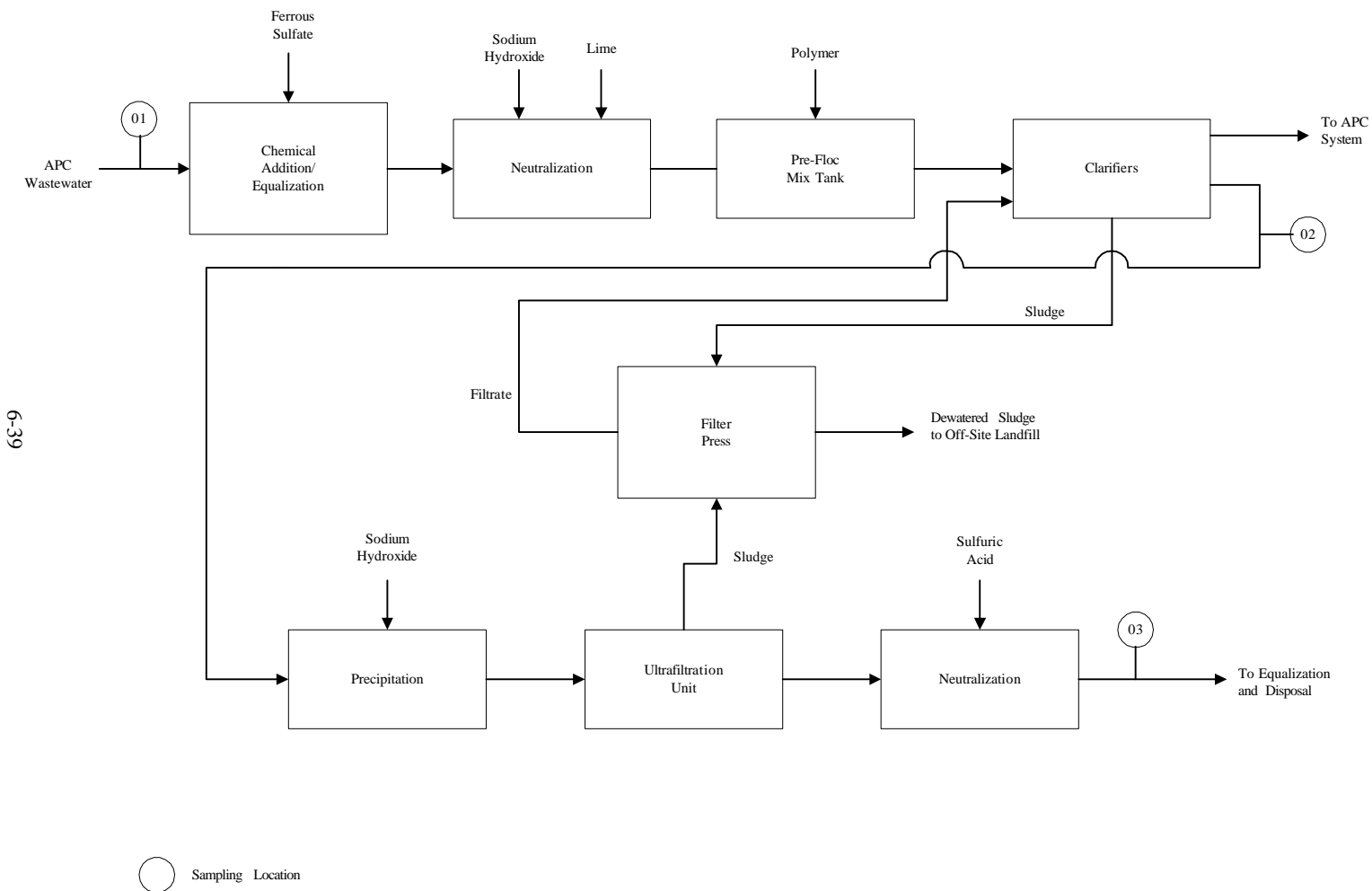


Table 6-3. Treatment Technology Performance for Facility 4671

Pollutant of Interest	CAS #	First Stage Chemical Precipitation Sample Points 1 to 2						Second Stage Chemical Precipitation Sample Points 2 to 3					
		DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal
<b>Conventional</b>													
TSS	C-009	4,000	01	241,100	02	70,900	70.6	4,000	02	70,900	03	13,800	80.5
<b>Non-Conventional</b>													
COD	C-004	5,000	01	259,400	02	227,600	12.3	5,000	02	227,600	03	154,800	32.0
TDS	C-010		01	7,481,000	02	6,896,000	7.8		02	6,896,000	03	6,560,000	4.9
<b>Metals</b>													
Aluminum	7429905	200	01	1,575	02	266	83.1	6.5	02	266	03	ND	97.6
Antimony	7440360	20.0	01	110	02	107	2.5	20.0	02	107	03	94.2	12.2
Arsenic	7440382	10.0	01	19.2	02	19.9	0.0	10.0	02	19.9	03	25.6	0.0
Boron	7440428	100	01	1,723	02	1,219	29.2	100	02	1,219	03	1,069	12.3
Cadmium	7440439	5.0	01	4.2	02	2.4	43.1	5.0	02	2.4	03	0.4	83.6
Chromium	7440473	10.0	01	124	02	3.2	97.4	10.0	02	3.2	03	1.0	67.7
Copper	7440508	25.0	01	121	02	33.8	72.0	25.0	02	33.8	03	18.8	44.4
Iron	7439896	100	01	1,217	02	79.8	93.4	100	02	79.8	03	50.1	37.1
Lead	7439921	50.0	01	149	02	14.3	90.4	1.5	02	14.3	03	ND	89.5
Manganese	7439965	15.0	01	107	02	74.3	30.5	15.0	02	74.3	03	2.3	96.9
Mercury	7439976	0.2	01	0.7	02	0.4	33.8	0.2	02	0.4	03	ND	54.5
Molybdenum	7439987	10.0	01	69.7	02	66.6	4.5	10.0	02	66.6	03	59.5	10.6
Selenium	7782492	9.7	01	ND	02	14.0	0.0	11.5	02	14.0	03	ND	17.6
Silver	7440224	10.0	01	5.7	02	9.1	0.0	10.0	02	9.1	03	2.0	77.7
Strontium	7440246	100	01	1,382	02	1,582	0.0	100	02	1,582	03	1,315	16.8
Tin	7440315	30.0	01	49.5	02	39.0	21.2	28.3	02	39.0	03	ND	27.4
Titanium	7440326	10.0	01	206	02	ND	95.1	10.0	02	ND	03	ND	0.0
Zinc	7440666	20.0	01	1,598	02	813	49.1	20.0	02	813	03	239	70.7
<b>Pesticides/Herbicides</b>													
Dichloroprop	120365	1.0	01	ND	02	NS	NS	1.0	02	NS	03	ND	NS
MCP	7085190	50.0	01	ND	02	NS	NS	50.0	02	NS	03	ND	NS

Negative percent removal are recorded as 0.0.

NS: Not Sampled

ND: Non-detect

DL: Specific detection limits of sample when there is a non-detect, otherwise it is the method detection limit

SP: Sample point.



Table 6-3 con't. Treatment Technology Performance for Facility 4671

Pollutant of Interest	CAS #	Entire Treatment System					
		Sample Points 1 to 3					
		DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal
<b>Conventional</b>							
TSS	C-009	4,000	01	241,100	03	13,800	94.3
<b>Non-Conventional</b>							
COD	C-004	5,000	01	259,400	03	154,800	40.3
TDS	C-010		01	7,481,000	03	6,560,000	12.3
<b>Metals</b>							
Aluminum	7429905	6.5	01	1,575	03	ND	99.6
Antimony	7440360	20.0	01	110	03	94.2	14.4
Arsenic	7440382	10.0	01	19.2	03	25.6	0.0
Boron	7440428	100	01	1,723	03	1,069	37.9
Cadmium	7440439	5.0	01	4.2	03	0.4	90.7
Chromium	7440473	10.0	01	124	03	1.0	99.2
Copper	7440508	25.0	01	121	03	18.8	84.5
Iron	7439896	100	01	1,217	03	50.1	95.9
Lead	7439921	1.5	01	149	03	ND	99.0
Manganese	7439965	15.0	01	107	03	2.3	97.8
Mercury	7439976	0.2	01	0.7	03	ND	69.9
Molybdenum	7439987	10.0	01	69.7	03	59.5	14.6
Selenium	7782492	9.7	01	ND	03	ND	0.0
		/11.5					
Silver	7440224	10.0	01	5.7	03	2.0	64.1
Strontium	7440246	100	01	1,382	03	1,315	4.8
Tin	7440315	28.3	01	49.5	03	ND	42.8
Titanium	7440326	10.0	01	206	03	ND	95.1
Zinc	7440666	20.0	01	1,598	03	239	85.1
<b>Pesticides/Herbicides</b>							
Dichloroprop	120365	1.0	01	ND	03	ND	0.0
MCP	7085190	50.0	01	ND	03	ND	0.0

Negative percent removal are recorded as 0.0.

NS: Not Sampled

ND: Non-detect

DL: Specific detection limits of sample when there is a non-detect, otherwise it is the method detection limit

SP: Sample point.

silver, and zinc, were low or not detected. Therefore, the influent concentrations for these parameters are close to the treatability levels using chemical precipitation, making it difficult to achieve additional removals for these pollutants. For example, cadmium was found in the influent and effluent of the primary treatment system at concentrations of 4.2 ug/l and 2.4 ug/l, respectively. This resulted in a percent removal of only 43.1 percent. Therefore, the low percent removal efficiency is a function of the low influent concentration (near treatability levels) and not indicative of poor performance.

The treatment efficiency of the secondary treatment system was evaluated using the data obtained from sampling points 02 and 03 (see Figure 6-14). Influent concentration data to the secondary system was obtained using sample point 02, which is the effluent from the primary system. Effluent from the secondary treatment system was represented by sample point 03. As demonstrated on the Table 6-3, the secondary treatment system removal rate for TSS was 80.5 percent. COD was removed at 32.0 percent, whereas, TDS was removed at 4.9 percent. Metals with high removal rates or removed to non-detectable levels in the secondary system include; aluminum, cadmium, chromium, lead, manganese, mercury, silver, tin, and zinc. Limited additional removals were observed for copper and iron. Poor removals were observed in the secondary system for antimony, boron, molybdenum, and strontium.

The treatment efficiency of the entire treatment system, both primary and secondary treatment system, was evaluated using the data obtained from sampling points 01 and 03 (see Figure 6-14). Influent concentration data was obtained using sample point 01. Effluent from the entire treatment system was represented by sample point 03. As demonstrated on the Table 6-3, the treatment system achieved good overall removals for TSS (94.3 percent). COD was removed at 40.3 percent, whereas, TDS was removed at 12.3 percent. Selenium, dichloroprop, and MCPP were not detected in the influent or effluent. Many of the metals observed in the influent were removed to levels exceeding 95 percent removal; these include aluminum, chromium, iron, lead, manganese, and titanium. Other metals also with high removals or removed to non-detectable levels include cadmium (90.7 percent), copper (84.5 percent), mercury (69.9 percent), silver (64.1 percent), and tin (42.8 percent). Poor removal efficiencies were observed for the entire treatment system for antimony (14.4 percent), boron (37.9 percent), molybdenum (14.6 percent), and strontium (4.8 percent). Arsenic was observed at below treatable levels throughout the system.

#### **6.4.1.3 Treatment Performance for Episode #4733**

EPA performed a week-long sampling program, episode #4733. This facility was evaluated by EPA to obtain performance data on various treatment units which are in operation at this facility, including sulfide precipitation, Lancy filtration, and carbon adsorption. A flow diagram of the IWC wastewater treatment system sampled during episode # 4733 is presented in Figure 6-15. The wastewater treatment system used at this IWC facility treats wastewater from the air pollution control system. The air pollution control system consists of a quench tank and a wet scrubber. Table 6-4 presents a summary of percent removal data collected at episode #4733 for the performance of the sulfide precipitation and Lancy filtration process, carbon adsorption system, and the entire treatment system.

The treatment efficiency of the sulfide precipitation and Lancy filtration system was evaluated using the data obtained from sampling points 01 and 02 (see Figure 6-15). Influent concentration data to the primary system was obtained using sample point 01. Effluent from the first-stage treatment system was represented by sample point 02. As demonstrated on the Table 6-4, the first-stage treatment system had non-detectable levels in the influent for TSS, aluminum, cadmium, lead, molybdenum, silver, strontium, and MCP. Other parameters were observed in the influent at levels near to or below treatable levels, such as antimony, arsenic, and copper. COD was removed at 11.8 percent, whereas, no removal was observed for TDS. Metals with high removal rates in the first-stage system include; chromium (84.4 percent), iron (85.3 percent), manganese (86.3 percent), mercury (94.0 percent), and zinc (92.2 percent). Titanium was removed to non-detectable levels in the first-stage system. The treatment system achieved limited removal of selenium through the first-stage primary system (25.6 percent). Poor to no removals were observed for boron and tin.

The treatment efficiency of the carbon adsorption system was evaluated using the data obtained from sampling points 02 and 04 (see Figure 6-15). Influent concentration data to the carbon adsorption system was obtained using sample point 02, which is also the effluent from the first-stage treatment system. Effluent from the carbon adsorption system was represented by sample point 04 which is also the effluent point for the entire treatment system. As demonstrated on Table 6-4, the carbon adsorption system had non-detectable levels in the influent for the same parameters

**Figure 6-15. EPA Sampling Episode 4733 - IWC Wastewater Treatment System Block Flow Diagram with Sampling Locations**

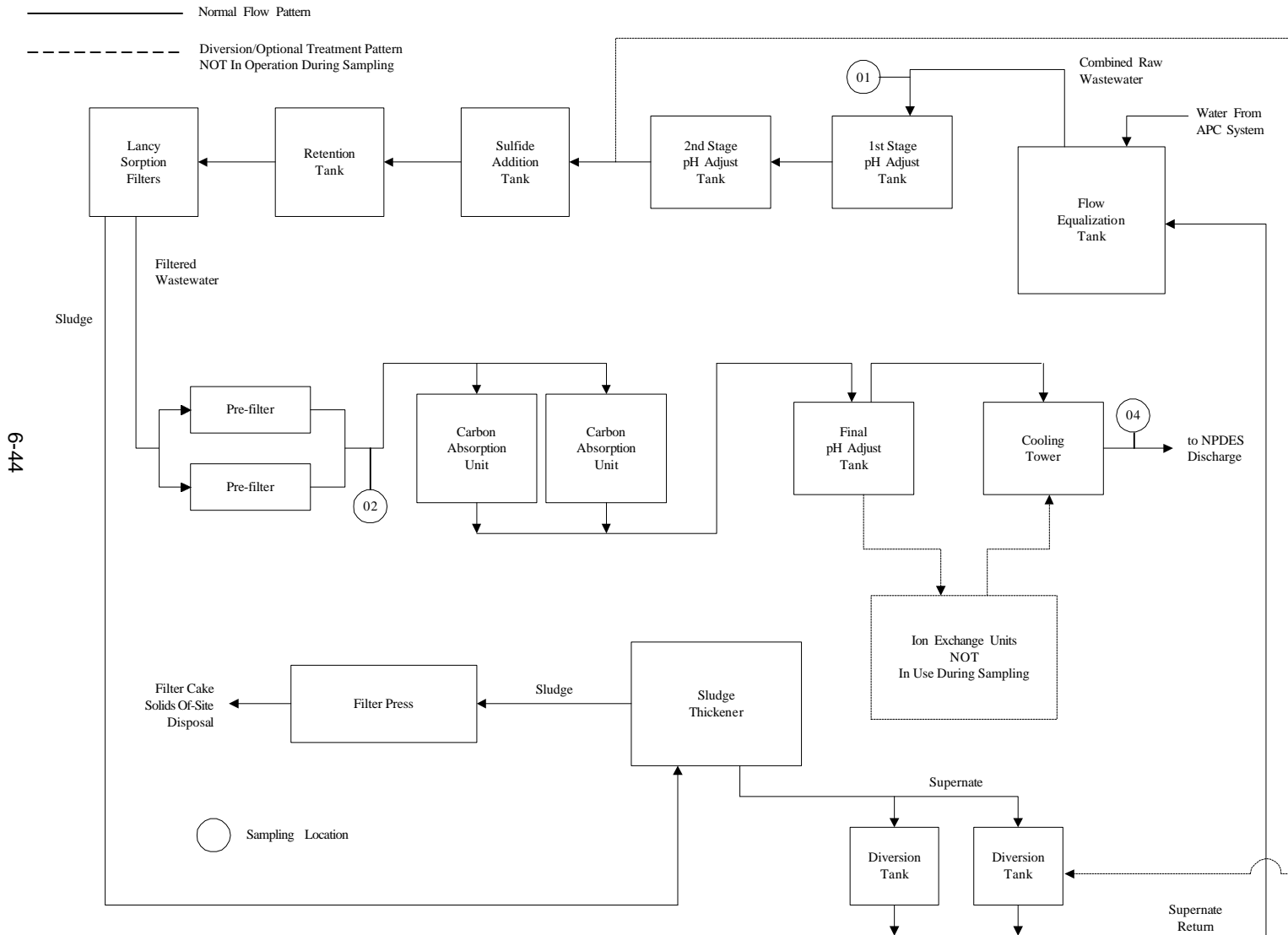


Table 6-4. Treatment Technology Performance for Facility 4733

		First Stage Lancy Filter Sample Points 1 to 2						Carbon Adsorption System Sample Points 2 to 4					
Pollutant of Interest	CAS #	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal
<b>Conventional</b>													
TSS	C-009	4,000	01	ND	02	ND	0.0	4,000	02	ND	04	ND	0.0
<b>Non-Conventional</b>													
COD	C-004	5,000	01	234,100	02	206,600	11.8	5,000	02	206,600	04	192,300	6.9
TDS	C-010		01	272,400	02	2,206,000	0.0		02	2,206,000	04	2,899,000	0.0
<b>Metals</b>													
Aluminum	7429905	13.6	01	ND	02	ND	0.0	13.6	02	ND	04	ND	0.0
Antimony	7440360	20.0	01	22.8	02	24.6	0.0	20.0	02	24.6	04	26.4	0.0
Arsenic	7440382	10.0	01	5.3	02	4.9	8.3	10.0	02	4.9	04	4.1	15.4
Boron	7440428	100	01	1,811	02	1,846	0.0	100	02	1,846	04	2,381	0.0
Cadmium	7440439	3.5	01	ND	02	ND	0.0	3.5	02	ND	04	ND	0.0
Chromium	7440473	5.8	01	37.1	02	ND	84.4	5.8	02	ND	04	ND	0.0
Copper	7440508	25.0	01	10.9	02	9.5	12.5	25.0	02	9.5	04	7.4	22.1
Iron	7439896	100	01	430	02	63.4	85.3	2.4	02	63.4	04	ND	96.2
Lead	7439921	2.1	01	ND	02	ND	0.0	2.1	02	ND	04	ND	0.0
								/1.8					
Manganese	7439965	1.2	01	8.8	02	ND	86.3	1.2	02	ND	04	1.3	0.0
Mercury	7439976	0.2	01	3.3	02	ND	94.0	0.2	02	ND	04	0.4	0.0
Molybdenum	7439987	4.6	01	ND	02	ND	0.0	4.6	02	ND	04	7.1	0.0
Selenium	7782492	5.0	01	59.1	02	43.9	25.6	5.0	02	43.9	04	56.5	0.0
Silver	7440224	7.8	01	ND	02	8.1	0.0	7.8	02	8.1	04	8.1	0.0
Strontium	7440246	100	01	ND	02	ND	0.0	100	02	ND	04	ND	0.0
								/86.7					
Tin	7440315	30.0	01	65.9	02	145	0.0	30.0	02	145	04	48.6	66.4
Titanium	7440326	5.0	01	11.4	02	ND	56.3	5.0	02	ND	04	ND	0.0
Zinc	7440666	20.0	01	102	02	7.9	92.2	2.4	02	7.9	04	ND	69.8
<b>Pesticides/Herbicides</b>													
Dichloroprop	120365	1.0	01	18.9	02	NS	NS	1.0	02	NS	04	ND	NS
MCP	7085190	50.0	01	ND	02	NS	NS	50.0	02	NS	04	ND	NS

Negative percent removal are recorded as 0.0.

NS: Not Sampled

ND: Non-detect

DL: Specific detection limits of sample when there is a non-detect, otherwise it is the method detection limit

SP: Sample point.

Table 6-4 con't. Treatment Technology Performance for Facility 4733

Pollutant of Interest	CAS #	Entire Treatment System					
		Sample Points 1 to 4					
		DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal
<b>Conventional</b>							
TSS	C-009	4,000	01	ND	04	ND	0.0
<b>Non-Conventional</b>							
COD	C-004	5,000	01	234,100	04	192,300	17.9
TDS	C-010		01	272,400	04	2,899,000	0.0
<b>Metals</b>							
Aluminum	7429905	13.6	01	ND	04	ND	0.0
Antimony	7440360	20.0	01	22.8	04	26.4	0.0
Arsenic	7440382	10.0	01	5.3	04	4.1	22.5
Boron	7440428	100	01	1,811	04	2,381	0.0
Cadmium	7440439	3.5	01	ND	04	ND	0.0
Chromium	7440473	5.8	01	37.1	04	ND	84.4
Copper	7440508	25.0	01	10.9	04	7.4	31.8
Iron	7439896	2.4	01	430	04	ND	99.4
Lead	7439921	2.1	01	ND	04	ND	0.0
		/1.8					
Manganese	7439965	15.0	01	8.8	04	1.3	85.2
Mercury	7439976	0.2	01	3.3	04	0.4	88.6
Molybdenum	7439987	4.6	01	ND	04	7.1	0.0
Selenium	7782492	5.0	01	59.1	04	56.5	4.4
Silver	7440224	7.8	01	ND	04	8.1	0.0
Strontium	7440246	100	01	ND	04	ND	0.0
		/86.7					
Tin	7440315	30.0	01	65.9	04	48.6	26.2
Titanium	7440326	5.0	01	11.4	04	ND	56.3
Zinc	7440666	2.4	01	102	04	ND	97.7
<b>Pesticides/Herbicides</b>							
Dichloroprop	120365	1.0	01	18.9	04	ND	94.7
MCP	7085190	5.0	01	ND	04	ND	0.0

Negative percent removal are recorded as 0.0.

NS: Not Sampled

ND: Non-detect

DL: Specific detection limits of sample when there is a non-detect, otherwise it is the method detection limit

SP: Sample point.

as in the first-stage system, plus the metals removed to non-detectable levels in the first-stage system, such as chromium, manganese, mercury, and titanium. Additional removals were observed for iron (96.2 percent), tin (66.4 percent), and zinc (69.8 percent). No removals in the carbon adsorption system were observed for boron and selenium. As in the first-stage system, antimony, arsenic, and copper are at concentrations in the influent below treatable levels.

The treatment efficiency of the entire treatment system, both first-stage sulfide precipitation, Lancy filtration, and carbon adsorption, was evaluated using the data obtained from sampling points 01 and 04 (see Figure 6-15). Influent concentration data was obtained using sample point 01. Effluent from the entire treatment system was represented by sample point 04. As demonstrated on Table 6-4, the treatment system achieved a COD removal of 17.9 percent, whereas, there is no removal for TDS. For the overall treatment system, the metals with high removal rates include chromium, iron, manganese, mercury, titanium, and zinc. Poor removals were observed for selenium and tin. Other metals were only detected at concentrations at or near treatable levels. Dichlorprop was removed to non-detectable levels at 94.7 percent. MCPP was not detected in the influent or effluent from the treatment system.

#### **6.4.2      *Rationale Used for Selection of BAT Treatment Technologies***

This section presents the rationale used in selecting the treatment technologies used in the proposed regulatory options. Treatment technologies used at episode 4733 were not considered for further evaluation, since influent concentrations for many parameters were low and performance data for the treatment systems could not adequately be ascertained. Therefore, the technologies utilized at episodes 4646 and 4671 were further evaluated in order to select the most appropriate technologies to be used as the basis for the BAT options. The basis of this evaluation consists of a comparative analysis of the performance data for the proposed BAT treatment technologies based upon EPA sampling data.

Table 6-5 presents a summary of the percent removal data collected at EPA sampling episodes 4646 and 4671 for the primary chemical precipitation systems. As demonstrated on this table, both chemical precipitation systems achieved similar removals for many of the same metal parameters. Although the loadings for some metal parameters were lower for episode 4671 which resulted in

Table 6-5. Primary Chemical Precipitation Treatment Technology Performance Comparison

		4646 First Stage Chemical Precipitation Sample Points 1+2 to 4						4671 First Stage Chemical Precipitation Sample Points 1 to 2					
Pollutant of Interest	CAS #	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal
<b>Conventional</b>													
TSS	C-009	4,000	01+02	122,560	04	11,200	90.9	4,000	01	241,100	02	70,900	70.6
<b>Non-Conventional</b>													
COD	C-004	5,000	01+02	535,920	04	156,200	70.9	5,000	01	259,400	02	227,600	12.3
TDS	C-010		01+02	30,694,160	04	50,320,000	0.0		01	7,481,000	02	6,896,000	7.8
<b>Metals</b>													
Aluminum	7429905	200	01+02	1,104	04	170	84.6	200	01	1,575	02	266	83.1
Antimony	7440360	20.0	01+02	672	04	1,026	0.0	20.0	01	110	02	107	2.5
Arsenic	7440382	10.0	01+02	475	04	494	0.0	10.0	01	19.2	02	19.9	0.0
Boron	7440428	100	01+02	1,280	04	1,744	0.0	100	01	1,723	02	1,219	29.2
Cadmium	7440439	5.0	01+02	929	04	174	81.2	5.0	01	4.2	02	2.4	43.1
Chromium	7440473	10.0	01+02	220	04	53.4	75.8	10.0	01	124	02	3.2	97.4
Copper	7440508	25.0	01+02	5,228	04	321	93.9	25.0	01	121	02	33.8	72.0
Iron	7439896	100	01+02	7,066	04	254	96.4	100	01	1,217	02	79.8	93.4
Lead	7439921	50.0	01+02	4,691	04	117	97.5	50.0	01	149	02	14.3	90.4
Manganese	7439965	15.0	01+02	228	04	76.6	66.5	15.0	01	107	02	74.3	30.5
Mercury	7439976	0.2	01+02	59.2	04	21.4	63.9	0.2	01	0.7	02	0.4	33.8
Molybdenum	7439987	10.0	01+02	936	04	1,137	0.0	10.0	01	69.7	02	66.6	4.5
Selenium	7782492	5.0	01+02	240	04	263	0.0	9.7	01	ND	02	14.0	0.0
Silver	7440224	10.0	01+02	283	04	169	40.3	10.0	01	5.7	02	9.1	0.0
Strontium	7440246	100	01+02	408	04	328	19.7	100	01	1,382	02	1,582	0.0
Tin	7440315	30.0	01+02	1,882	04	45.9	97.6	30.0	01	49.5	02	39.0	21.2
Titanium	7440326	5.0	01+02	2,116	04	32.9	98.4	10.0	01	206	02	ND	95.1
Zinc	7440666	20.0	01+02	9,456	04	209	97.8	20.0	01	1,598	02	813	49.1
<b>Pesticides/Herbicides</b>													
Dichloroprop	120365	1.0	01+02	3.1	04	NS	NS	1.0	01	ND	02	NS	NS
MCPP	7085190	50.0	01+02	1,027	04	NS	NS	50.0	01	ND	02	NS	NS

Negative percent removal are recorded as 0.0.

NS: Not Sampled

ND: Non-detect

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SP: Sample point.



lower percent removals, the overall concentrations for some of the pollutants were treated to similar concentration levels as those for episode 4646. For instance, manganese percent removal for episode 4671 was only 33.8 percent, however the effluent concentration of 74.3 ug/l was comparable to that of episode 4646 of 76.6 ug/l during which a 66.5 percent removal was achieved. Metals which experienced good overall removals in both chemical precipitation treatment systems include aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, tin, titanium, and zinc. Neither system was effective in treating antimony, arsenic, boron, selenium, silver, and strontium. Episode 4646 had higher removals for TSS (90.9 percent) and COD (70.9 percent).

Next, an evaluation of the secondary precipitation process plus filtration for both facilities was performed. Table 6-6 presents a summary of the percent removal data collected at EPA for sampling episodes 4646 and 4671 for the secondary precipitation process and sand filter or ultrafiltration process, respectively. As demonstrated on this table, either process resulted in low effluent concentrations for many of the metal parameters; such as cadmium, chromium, copper, iron, lead, mercury, and zinc. However, the most significant difference between the two systems is the removal of antimony (66.3 percent), arsenic (98.4 percent), and selenium (90.1 percent) in the secondary system for episode 4646. Episode 4671, which employs a secondary treatment system consisting of hydroxide precipitation and ultrafiltration, did not achieve significant removals for antimony, arsenic, or selenium.

Overall both facilities achieved similar removals and/or treated to the same degree for many of the metal parameters which are readily removed by chemical precipitation using sodium hydroxide; including but not limited to cadmium, chromium, copper, iron, lead, mercury, and zinc. Both facilities utilized a two tiered approach in the design of their treatment system using some type of a chemical precipitation process to provide treatment. Primary treatment system design are comparable at both facilities and are designed to remove similar pollutants. Both primary treatment systems are designed to remove those metals which readily precipitate out of solution at a high pH range using a sodium hydroxide precipitation treatment process. Based upon EPA sampling data, this treatment process was determined not to be very effective in treating antimony, arsenic, boron, selenium, silver, and strontium. The treatment system at episode 4671 uses a secondary treatment system targeted to achieve additional removals for the same parameters which receive initial removals in the primary

Table 6-6. Secondary Chemical Precipitation and Filtration Treatment Technology Performance Comparison

		4646 Second Stage Chemical Precipitation& Sand Filtration Sample Points 4 to 6						4671 Second Stage Chemical Precipitation & Ultrafiltration Sample Points 2 to 3					
Pollutant of Interest	CAS #	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal	DL	sp	Influent Conc. (ug/l)	sp	Effluent Conc. (ug/l)	% Removal
<b>Conventional</b>													
TSS	C-009	4,000	04	11,200	05	5,500	50.9	4,000	02	70,900	03	13,800	80.5
<b>Non-Conventional</b>													
COD	C-004	5,000	04	156,200	05	257,900	0.0	5,000	02	227,600	03	154,800	32.0
TDS	C-010		04	50,320,000	05	38,150,000	24.2		02	6,896,000	03	6,560,000	4.9
<b>Metals</b>													
Aluminum	7429905	200	04	170	05	160	5.9	6.5	02	266	03	ND	97.6
Antimony	7440360	20.0	04	1,026	05	346	66.3	20.0	02	107	03	94.2	12.2
Arsenic	7440382	10.0	04	494	05	8.1	98.4	10.0	02	19.9	03	25.6	0.0
Boron	7440428	100	04	1,744	05	1,731	0.7	100	02	1,219	03	1,069	12.3
Cadmium	7440439	5.0	04	174	05	19.9	88.6	5.0	02	2.4	03	0.4	83.6
Chromium	7440473	10.0	04	53.4	05	ND	81.3	10.0	02	3.2	03	1.0	67.7
Copper	7440508	25.0	04	321	05	10.1	96.9	25.0	02	33.8	03	18.8	44.4
Iron	7439896	100	04	254	05	128	49.6	100	02	79.8	03	50.1	37.1
Lead	7439921	50.0	04	117	05	ND	57.3	1.5	02	14.3	03	ND	89.5
Manganese	7439965	15.0	04	76.6	05	545	0.0	15.0	02	74.3	03	2.3	96.9
Mercury	7439976	0.2	04	21.4	05	ND	99.1	0.2	02	0.4	03	ND	54.5
Molybdenum	7439987	10.0	04	1,137	05	580	49.0	10.0	02	66.6	03	59.5	10.6
Selenium	7782492	5.0	04	263	05	26.0	90.1	11.5	02	14.0	03	ND	17.6
Silver	7440224	10.0	04	169	05	ND	94.1	10.0	02	9.1	03	2.0	77.7
Strontium	7440246	100	04	328	05	674	0.0	100	02	1,582	03	1,315	16.8
Tin	7440315	30.0	04	45.9	05	31.5	31.4	28.3	02	39.0	03	ND	27.4
Titanium	7440326	5.0	04	32.9	05	6.8	79.3	10.0	02	ND	03	ND	0.0
Zinc	7440666	20.0	04	209	05	24.2	88.4	20.0	02	813	03	239	70.7
<b>Pesticides/Herbicides</b>													
Dichloroprop	120365	1.0	04	NS	05	ND	NS	1.0	02	NS	03	ND	NS
MCP	7085190	50.0	04	NS	05	1,482	NS	50.0	02	NS	03	ND	NS

Negative percent removal are recorded as 0.0.

NS: Not Sampled

ND: Non-detect

DL: Specific detection limits of sample when there is a non-detect, otherwise it is the method detection limit

SP: Sample point.

system. Chemical precipitation by hydroxide precipitation is once again utilized with ultrafiltration as a polishing step in the secondary system. The design of this treatment system is primarily due to the characteristics of the wastewater at this facility, as well as a function of the discharge limitations in their NPDES permit. During the sampling episode, the facility for episode 4671 was permitted for antimony (2,000 ug/l daily maximum) and for arsenic (100 ug/l daily maximum). However, neither of these two parameters were observed in the influent at levels above their respective discharge limitation in EPA's sampling episode. Therefore, the design and operation of the treatment system at episode 4671 is not driven by the removals of parameters such as antimony or arsenic, but rather by other metals which are removed by hydroxide precipitation; such as aluminum. Conversely, the facility for episode 4646 is designed to remove those metals in the secondary treatment process which are not readily removed by hydroxide precipitation. At the time of the sampling episode, this facility's NPDES permit contains discharge limitations for antimony (600 ug/l daily maximum), arsenic (100 ug/l daily maximum), selenium (100 ug/l daily maximum), and silver (100 ug/l daily maximum). Each of these parameters were observed in the influent to the treatment system at concentrations over their respective discharge limitation. Therefore, the wastewater treatment system used at episode 4646 is designed and operated with a secondary treatment system consisting of chemical precipitation at a low pH range by ferric chloride and multimedia filtration aimed at removing these additional metal parameters which are not removed by hydroxide precipitation in the primary treatment system.

Based upon the results of the above comparative analysis of chemical precipitation and filtration processes used at IWC facilities sampled by EPA, the proposed regulatory options utilize unit treatment processes such as those found at episode 4646. Performance data from this facility indicates that a primary chemical precipitation system utilizing a sodium hydroxide precipitation process can readily achieve high removals for many metal parameters. A secondary system consisting of chemical precipitation using ferric chloride and sand filtration can effectively remove additional metals not readily removed by hydroxide precipitation, such as antimony, arsenic, and selenium, as well as, achieve high additional removals for other metals which are removed by hydroxide precipitation. Therefore, the combining of these treatment processes results in a highly effective treatment operation which can readily accommodate the pollutants of interest for the IWC industry.